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This report was prepared for the Mackenzie River Basin Committee. Any conclusions, recommendations or opinions expressed herein are those of the authors and are not necessarily the same as those of the Committee.

Cover Photo: Mackenzie River at
Fort Simpson, Northwest
Territories, looking downstream

Mackenzie River Basin Committee

Slave River Delta

Mackenzie River Basin Study Report Supplement 6

A report under the 1978-81 Federal-Provincial Study Agreement respecting the water and related resources of the Mackenzie River Basin.

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EXECUTIVE SUMMARY

This report contains the results of the Slave River Delta Study which was undertaken as part of the three year (1978-81) Mackenzie River Basin Study Program. The delta was examined because of the serious deficiency of baseline information required to understand the relationships between its biological resources and hydrologic regime. In order to properly understand these relationships it was necessary to examine the origin and present state of the delta and its hydrologic regime; the fish, bird, and aquatic furbearer resources, and their relationships to delta hydrology.

Geomorphological changes were identified through analysis of a series of airphotos (1930-79) and landsat images (1972-80). Water samples were collected and flow rates and levels recorded at gauging stations between 1978-80. Aerial surveys (1978-80) were useful in determining the relative status of waterfowl species and muskrat and their habitats. Nets and live-traps were used to collect specimens to tag and monitor species movement. Ground surveys were used to determine habitat use and brood productivity of bird and muskrat populations. Laboratory analysis determined water quality parameters and ages and productivities of fish and muskrat populations. A summary of the results of these

investigations follows.

A. Geomorphology and Hydrology

The Slave River Delta has prograded alternately on the west and east sides of the Slave River and shorelines on opposite sides of the river have been stationary or retreating. The shoreline of the active delta has been advancing out into Great Slave Lake at three kilometers per century. Delta hydrology and sedimentation, particularly inundations by annual flood waters carrying nutrient-rich sediments which replenish water and deposit fresh sediments, are the main control factors in the change and vitality of the delta. Periglacial isostatic rebound and long term progradation of the delta appear responsible for the low gradient of the Slave River. ResDelta Channel carries the bulk of the summer flows (86%), while Middle Channel West carries nine percent with the remainder carried in the five remaining main channels. Variations in flood levels range up to three meters. Two different types of breakup were observed. In 1979 it was late, and had high water levels and extensive flooding. Breakup in 1980 was later, warm, and experienced low flows and minimal flooding. Winter flows were reduced to negligible levels in some of the smaller distributary channels. The quality of the water samples collected in the delta showed little difference from those collected at Fort Smith and was normal for northern rivers. Turbidity and suspended sediment loads were greatest during spring flood, 350-800 FTU and 1000-2000 mg/L, respectively. Normal ranges were 90 to 40 FTU and 150 to 20 mg/L from summer to winter. Dissolved oxygen was greatest during cold open water periods and lowest in the summer when water temperatures reached 21° C.

B. Fish

Chemical analysis of the water showed that it was well within the tolerance limits of most sensitive fish. In shallow waters the silty substrate was dominated by oligochaetes and chironomids. Caddis fly and mayfly larvae were more common in deeper waters. Twenty-four species of fish utilize the delta of which eight are considered incidental. Northern pike, emerald shiners, flathead chub and trout perch are considered abundant and resident. Inconnu, lake whitefish and spoonhead sculpin migrate through the delta, while goldeye, longnose suckers and walleye feed in the delta during the open water period. Burbot and small bodied cisco spawn in the delta, principally in ResDelta Channel. Small fish and young-of-the-year are abundant in the shallow, well vegetated areas in late spring and summer.

C. Birds

An estimated 5,200 breeding pairs of waterfowl were recorded in 1978. The incubation period lasted from May 28 to July 17 and brood production was very low. The primary value of the delta is as a migratory stop for migrating waterfowl in the spring and fall. The delta is part of a larger staging area between Fort Resolution and Talston Bay on the south shore of Great Slave Lake. In 1978, waterfowl at their peak numbered 7,600, with an additional 7,700 swans and 4,700 geese. In the spring of 1979, 10,300 ducks, 5,400 swans and 5,300 geese were recorded. Common passerine birds recorded in the delta included Yellow and Yellow-rumped warblers, Common Snipe, White-throated and Tree sparrows, Least Flycatcher and Red-eyed Vireo. Colonies of Arctic Terns and California Gulls were found on the sandspits of the outer delta.

Over 3,000 shorebirds were recorded in 1978. Two active Bald Eagle and one Osprey nest were found in the study area.

D. Muskrats

Large numbers of muskrat houses were mapped in the outer delta prior to the spring of 1977 but drastically declined after the population crash of the winter of 1976-77. In the winter the houses are exposed to severe northwest winds, severe cold and shallow snowcover and are abandoned. Optimal sites for dens are burrows along the active distributaries, with moderate slopes and heavy littoral vegetation. These sites also offer access to late winter forage created by hang-ice conditions.

Placental scars showed a high productivity for muskrats in the Slave Delta, with a three-year average of two litters and 8.7 litter size. In 1980 conditions may have been favourable for a third litter. The percentage of sub-adult in the fall harvest was 77.1 percent over the three years. Summer survival rates are very low for juveniles. Natural population controls include predation, freezing out, epizootics and interspecific fighting.

E. International, Regional, and Local Significance

The biological resources of the Slave River Delta and their relatively high productivity are dependent on the hydrologic regime of the Slave River. The delta is important as a major migratory corridor for whitefish and inconnu in the fall and, as a fall spawning area for burbot and small-bodied cisco. The warm, vegetated shallows of the delta are heavily utilized by young-of-the-year and small prey species which form an integral part of the food chain. Harvests of spawning and migratory fish spacies also are of importance to the local economy of Fort Resolution.

The Slave River Delta is situated between the Mills-Beaver Lakes complex and the Peace-Athabasca Delta on a number of major flyways. Although the total number of ducks that utilize the area for staging and breeding is less than the areas to the north and south it is very important as a staging area for swans and geese. The relative abundance of waterfowl in the delta is reflected in the heavy native harvest.

The most important biological resource harvested by the natives of Fort Resolution is the muskrat, both for pelts and country food. The delta's harvest is second only to Inuvik and the Mackenzie Delta. The delta is highly productive compared to the surrounding boreal forest due to the periodic flooding, sediment deposition and successional vegetation growth (emergent/aquatic/sub-aquatic).

F. Sensitivity to Hydrologic Regime Change

Altering of the upstream hydrologic regime could seriously affect the timing of the spring flood in the delta, its magnitude and duration. The main part of the flow of the Slave River Delta has shifted to the east into the enlarging Res Delta Channel. With the majority of the flow in one channel, periodic flooding is critical to deposition of nutrient-rich sediments and recharging water levels in other parts of the delta. Changes in vegetation patterns as a result of regime changes could seriously affect wildlife habitats.

Any reductions in flow rates, flooding, and sediment deposition could ultimately affect delta size and productivity. The fish population could be reduced, especially the young-of-the-year, because of diminished habitat, as could migratory waterfowl species. The loss of flood peaks and eventual stabilizing of vegetation patterns, could also reduce critical wintering habitats for muskrat populations.

G. Recommendations

An additional five years of hydrologic records are needed for the Slave River Delta before the hydrology of the delta can be adequately understood. In addition to monitoring stream flows, an effort should be made to determine the migration timetable and spawning sites of the fish populations passing through or spawning in the delta. It is also recommended that the relationship between the hydrologic regime and muskrat population be studied for two complete population cycles. A smaller study should should examine the role of natural mortality as a population check.

Indian and Northern Affairs Canada
Affaires indiennes et du Nord Canada

Water Resource Division
P.O. Box 1500
Yellowknife, N.W.T.
X1A 2R3

October 27, 1981

Your file Votre référence

Our file Notre référence

Mr. Hans Foerstel
Inland Waters Directorate
Environment Canada
1901 Victoria Avenue
Regina, Saskatchewan
S4P 3R4

Dear Mr. Foerstel,

Enclosed is a copy of Technical Supplement No. 6 entitled the Slave River Delta which was edited by K. Bodden of the Boreal Institute for Northern Studies. The supplement is a compilation of the final reports from each of the five study components which respectively investigated the historic development of the Slave River Delta, its hydrology and its furbearer, fish and bird resources.

The Slave River Delta Study was administered by the Water Resources Division of the Department of Indian Affairs and Northern Development (DIAND) in Yellowknife and was conducted in accordance to the conditions specified in the Memorandum of Understanding between Environment Canada, on behalf of the Mackenzie River Basin Committee, and DIAND Northern Affairs Program, Water Resources Division, Yellowknife which was signed on April 1, 1978.

Sincerely,

Serge Metikosh

S. Metikosh
Sr. Aquatic Biologist
Water Resources Division

SM/mm

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CHAPTER I

PREFACE

The Slave River Delta Study was multidisciplinary in nature and was composed of the following five research components: geomorphological origin and change; hydrology; fish; birds; and muskrats. The objectives of the study were to:

- describe the historical development, rate of change and stability of the major distributary channels;
- identify the control factors that create change in the delta and maintain its vitality and productivity;
- determine the suspended sediment load and quality of water within the delta;
- determine the flow patterns, flood level fluctuations and frequency in the major distributary channels;
- describe the life histories, seasonal movements and relative status of the fish, macroinvertebrates, waterfowl and aquatic furbearer species, document their habitat selection and utilization in relation to existing conditions;
- and determine their sensitivity to changes in the hydrologic regime.

Although the studies were coordinated as a single study program, each of the five components was undertaken by separate contractors. This technical supplement presents the final reports of each contributor in a single volume. These reports are preceded in this supplement by an Executive Summary, Synthesis, and Background Information. The Executive Summary and Synthesis were written on the basis of material contained in the five component reports.

The Background Information provides a brief summary of the delta and Fort Resolution based on material published prior to the completion of the study. The Background Information is provided to give the 'state of the art' for the subject areas being examined in greater detail and to provide information on the physical setting of the delta, its other biological resources and human settlement.

CHAPTER II

SYNTHESIS

A. Significance of Biological Factors

The Slave River Delta Study represents an attempt to reduce the baseline information deficiencies on the importance of the delta's biological resources, and how they and the physical environment of the area are affected by biophysical factors such as hydrology and sedimentation. The multidisciplinary aspect of the study, using five specialized research projects, provided the opportunity to examine more closely the interrelationships between environmental factors as well as provide general information on the biological resources.

The significance of the biological resources of the Slave River Delta is directly related to the diversity and productivity of the habitats in comparison to the adjacent boreal forest. The small area of wetlands, sandbars, interlevee depressions and distributary channels acts as a biological oasis in the relatively unproductive boreal ecosystem. Successional areas of littoral (aquatic and semi-aquatic) vegetation are good breeding, rearing, feeding and shelter habitats and are used by fish and wildlife populations characterized by high species diversity and densities.

Located on the Atlantic, Mississippi and Central flyways, the Slave River Delta is very important to spring and fall waterfowl migrations. Estimates of up to 225,000 ducks, 300,000 geese and 60,000 swans utilize the flyways through the delta. The sandbars and interlevee scrolls of the outer delta, serve as prime staging habitats for migrating waterfowl and shorebirds. Over 5,000 breeding pairs of ducks were recorded using the delta for brood production. During periods of drought conditions on the main breeding areas of the prairies, it is thought that ducks move northward to areas of more stable water conditions in the boreal forest, such as the delta, to utilize these important alternative nesting sites.

On a regional scale the delta is important to the fish populations of Great Slave Lake, migratory waterfowl and muskrats. The large distributary channels of the delta serve as major spawning sites for burbot and small-bodied cisco. These species are not of commercial value but provide a valuable source of human and animal feed and are harvested by the natives of Fort Resolution and other settlements on Great Slave Lake. The cisco are an integral part of the diet of the large predator fishes of the lake. The delta serves as a major migration corridor for commercially and domestically important fish species such as lake whitefish, inconnu, northern pike and walleye. These fish pass through the delta travelling to and from spawning habitats upstream on the Slave River. Only a few large fish species feed directly on the abundant macroinvertebrate populations of the delta's silty substrate. Subsequently, the large number of young-of-the-year and small prey species utilizing the vegetated shallows of the delta for shelter and feeding are significant as a link in the energy transfer from the deltaic invertebrates to the larger fish species feeding in the delta during open water or migrating through in the spring or fall.

The Slave River Delta is one of the three main waterfowl breeding areas in the boreal forest region. Both the Mills-Beaver Lakes complex and the Peace-Athabasca Delta support larger waterfowl brood numbers and are utilized by ducks more than the Slave Delta. However, the numbers of geese and swans that utilize the delta are comparable or larger on a per unit basis.

The muskrat population of the delta represents the major concentration of fur resources between the Peace-Athabasca and Mackenzie deltas. Annual harvests are ranked behind those of Inuvik and the Mackenzie Delta but in terms of harvest area, they are very significant to the territorial fur industry.

The natural resources of the Slave River Delta provide an important and intergal source of income and country food for the residents of Fort Resolution. The yearly harvest of fish and game resources from the study area is substantial with an estimated $222,000 and $192,000 in furs and imputed value of country food for 1975-76 and 1976-77, respectively. These figures represent 35.6 percent and 27.5 percent of the native economy of Fort Resolution for the harvest years mentioned (July-June).

Fish have traditionally been and still remain an important source of human and animal food for residents on the south shore of Great Slave Lake. Located within the protected 10-mile domestic fishery zone, the delta provides burbot, inconnu and lake whitefish for native diets. Burbot, inconnu and longnose suckers are used primarily for animal feed.

The large numbers of waterfowl staging in the delta for two to four week periods each year attracts heavy native hunting pressure. Large numbers of ducks and geese are taken and used exclusively for human consumption. An estimated 4,000 ducks and 400-600 geese are harvested annually. These figures also include an unknown percentage of swans and shore birds.

The muskrat population of the Slave River Delta represents the single most important resource harvested in terms of cash from fur sales and human and animal food. An estimated 37,000 muskrats were harvested from the delta in 1975-76 and generated over $89,000 in fur sales. In addition, an estimated $54,000 in country food was created by the use of the carcasses for food during the same time period. The muskrat harvest appears to be controlled by the relative status of the population and fur prices, with population numbers being the better indicator of hunting and trapping activity.

Despite the opportunity to engage in and become economically dependent on wage employment locally or in adjacent south shore locations, the native population of Fort Resolution has opted to develop a local economy that blends wage employment, transfer payments and subsistence hunting/trapping/fishing activities. Following a history of exposures to the advantages and disadvantages of development, the natives of the community have attempted to and appear to have maintained a close and economically viable contact with their natural environment and the biological resource base of the Slave River Delta.

B. Environmental Sensitivity

Two environmental factors examined by the study appeared to exert more control over the biological resources of the delta than the others. The hydrology of the Slave River and its associated sediment load were identified as the most significant factors in the Delta's high productivity by maintaining the structure in a non-climax state. The composition and numbers of fish and wildlife populations and vegetation forms and patterns are controlled by these two factors and are expected to be sensitive to any modifications in the Slave River's regime or sediment load.

Northern rivers are characterized by a peak flow shortly after spring breakup and these flood waters are instrumental in the development and maintenance of deltaic forms. The Slave River Delta experiences periodic flooding. Break-up of the river and resulting open water early in the season lowers the local albedo and creates a warmer micro-climate than the surrounding boreal forest. The level of the annual influx of sediment-laden water is often increased by ice jams in the distributary channels of the delta, and the resulting flood recharges the abandoned distributary channels and interbasin lakes with nutrient-rich sediments and helps to restore water levels. Spring floods flush ice from the channels and ice scouring of the flood plain and alluvial flats occurs during breakup.

The most significant result of the spring flood is the creation and maintenance of highly productive littoral (semi-aquatic and aquatic) vegetation communities in early successional stages.

Unlike boreal wetland habitats that evolve from productive successional stages to non-productive climax spruce forests through build-up of litter and other depositional matter, the Slave Delta experiences spring flooding and ice scouring which stops or reverses the colonization by willows and related successionally advanced terrestrial species. The combination of warm temperatures, longer growing season, adequate water levels and periodic rejuvenation of soil nutrients supports successful communities of pioneering species such as Equisetum and Salix-Equisetum. These riparian or shoreline communities are adapted to periodic flooding. These plant communities create prime shelter and feeding habitats for the fish, water-fowl and mammal populations of the delta.

The sediment load of the Slave River is another control factor of the hydrologic regime affecting the development of the diverse habitats of the delta. The Slave River Delta exists as a result of fluvial deposition caused by the reduced velocity and carrying capacity of sediment of the Slave River as it flows into Great Slave Lake. The older upstream portions of the delta have developed structures typical of drier and more stable conditions, while the young outer downstream sections exhibit shoals and silt bar developments. The tendency of the distributary channels to flare into plumes when they enter the lake results in mid-channel depositional forms such as underwater levees. The continued growth of the outer delta creates rich and diverse shoreline habitats for fish and wildlife species. The river contributes sediments at a faster rate than wind, wave, or lake current erosion can remove them and ensures the continued, if erratic, growth of the outer delta.

Because of its hydroelectric potential, future development of the Slave River is a possibility. Although it was not within the scope of this study to determine the magnitude of change resulting from a potential altering of the hydrologic regime, it is possible to estimate the effects such development could have on the vegetation patterns and landscape of the delta. It is expected that the present frequent flooding of the delta could be reduced through regulation of the Slave River.

The loss of spring flood waters could affect the climate of the delta, lowering temperatures and delaying phenology or bud-burst. The following discussion will identify some of the short-term effects on the biological resources of the delta based on the knowledge of the interrelationship between the fish and wildlife populations and the hydrologic regime of the delta.

The dominant resident populations of fish utilizing the delta appears to be the young-of-the-year and the small minor species such as lake chub, emerald shiners, and pearl dace. These species consitute a large part of the diet of the larger major fish species that utilize the delta as a fall migration corridor to spawning grounds upstream (lake whitefish, inconnu, walleye). These are also important to the resident northern pike population and to burbot and ciscoes which spawn in the ResDelta Channel in the fall. Reductions in flow rates could reduce the amount of littoral vegetation. A reduction of these shallow, well-vegetated habitats which serve as shelter and feeding areas for the prey species would ultimately reduce the prey populations. If on a large enough scale, flow reductions may ultimately affect the spawning and migration behaviour of fish utilizing the delta. The use of the delta as a nursery area for young-of-the-year could also diminish if water levels drop in the minor distributary channels. Accessiblity to distributary channels and interlevee basin lakes could also be limited with reduced water levels. The loss of spring flood waters could also delay spring breakup and affect the spawn of the resident northern pike populations.

Waterfowl utilization of the delta begins when leads open along the main distributary channels. The spring flood breaks up and flushes the ice from the distributary channels and creates large areas of open water weeks ahead of the surrounding area. Large areas of Equisetum are exposed by the flushing action, providing needed feed for migrating ducks, swans and geese. An appreciable delay in spring breakup and the lack of open water and feed could be detrimental to waterfowl migrating further north where incubation periods are critically short. Reduced water levels and sedimentation could allow colonization by terrestrial plant species which are not digestable by waterfowl.

Low water levels persisting over an extended period could temporarily extend feeding areas to the outer delta but would soon be replaced by more advanced successional communities. Continued reductions in staging and feeding habitats could induce major changes in waterfowl migration patterns and timings. The loss of flood waters to recharge the water levels in the perched basins and snyes in the delta will result in a gradual drying out process and colonization by vegetation. The conversion of prime breeding areas to boreal vegetation could reduce the actual and potential brood production of the delta.

The prime staging and feeding habitats for swans and geese are found in the outer delta, where aquatic and semi-aquatic vegetation communities colonize the interlevee depressions. Reduction in the sediment load could stop the building process of the delta, resulting in the erosion of the active delta by wave, wind, and current action. The result could be a reduction in the delta's size, principally the shallow outer delta, and a gradual deepening of water off the lake edge of the delta, and a loss of prime staging habitat for swans and geese. The change to a more boreal-type vegetation could also result in different species using the area. Bufflehead and goldeye species would replace widgeon and mallards as common ducks. Habitat for passerines could become less diverse and species composition would change.

The muskrat population is dependent on the spring flood and the role it plays in maintaining riparian vegetation communities, especially horsetail (Equisetum fluviatile). A reduced spring flood could reduce these areas and eventually affect muskrat numbers which depend on the plants for food and shelter. Habitats with the minimum water depths necessary for muskrat survival (1.3-1.6 meters) could be reduced in area with reduced water levels. Continued low water levels into the winter months could allow channels to freeze to the bottom, restricting surviving overwintering populations to the main distributary channels.

The natural flow regime of the Slave River has been characterized by periods when flood peaks were very low and flooding was minimal. During these periods fish and wildlife populations were detrimentally influenced but have been able to survive through short-term adjustments, using alternative habitats, until conditions change. The diversity of habitats created by the spring flood allowed this behaviour change, but if the spring flood is lost or significantly reduced over a long time period the diversity of habitats will also be reduced, directly affecting fish and wildlife populations.

The construction of reservoirs and power generation capacities on the Slave River could result in long-term changes in the pattern of river discharge. Peak flow periods would be used to recharge the reservoir. Demand for power would regulate the amount of water allowed downstream and this fluctuation in water levels could make adjustments difficult for fish and wildlife resources.

C. Research Recommendations

The research components of the Slave River Delta Study have provided much needed baseline information on the physical processes active in the delta, its biological resources and the interrelationship of factors within the delta and to the larger Mackenzie River Basin. However, like the studies that preceded it, the Slave River Delta Study was conducted over a short time period (three years) and usually during the open water period. The material collected allows us to project general trends on how fish and wildlife resources react to changes created by altered hydrologic regimes. A number of detrimental effects of reduced spring floods and low water levels have been identified on short- and long-term bases but little is known of the magnitude of the change in either the hydrologic regime or on wildlife resources. General information is not adequate to properly gauge environmental change, especially in terms of muskrat populations, for example. The muskrats of the delta exhibit habitat selection and litter production characteristics of both the Peace-Athabasca and Mackenzie deltas depending on prevailing water conditions. During good water years litter size and numbers are high and houses are used, similar to muskrat populations in the Peace-Athabasca Delta. Conditions are closer to those found in the Mackenzie Delta (lower reproduction and bank burrowing) when water levels are low. Wise management decisions cannot be made based on extrapolations from a few years of observation and comparisons of data to known examples.

1. Hydrology

The hydrologic regime has been identified as the most important control factor in the delta. An additional five years of flow distribution measurements and spring breakup observations needs to be added to the three years of records so that a more complete range of flows can be used to evaluate potential interaction of elements within the delta.

2. Fish

More detailed information is needed on the spawning timetable and spawning grounds of the fish species spawning in or migrating through the delta. The spawning grounds below Fort Smith on the Slave River used by the commercially important lake whitefish, inconnu, and walleye need to be located. The limits and substrata characteristics of the burbot and cisco spawning sites in ResDelta Channel and the other major distributaries need to be identified. Tagging programs initiated in the vicinity of Fort Smith would also add to the information being collected from similar programs on Great Slave Lake.

3. Muskrat

The muskrats of the Slave River Delta use a number of habitats depending on prevailing water conditions. When water levels drop, winter houses are abandoned for bank burrows which may or may not have associated pushups. Under these conditions the lack of evidence of winter habitat use is not an accurate reflection of population numbers. Two complete population cycles need to be monitored for habitat and population changes with special emphasis on winter conditions. Live-trapping, tagging, and carcass collections should be continued over the same time period to determine population dynamics, home ranges, and identify prime over-wintering habitats.

CHAPTER III

BACKGROUND INFORMATION

A. INTRODUCTION

The deltas of the major rivers are among the most productive and ecologically sensitive areas in the Canadian North. Nutrient-rich alluvial deposits and their rejuvenation through periodic flooding supports extensive and diverse shoreline habitats. The Slave River Delta, located between the Peace-Athabasca and Mackenzie deltas, is the smallest of the three. The complex relationships between the physical and biological components of the delta are sensitive to changes in the river's hydrologic regime. The ecological sensitivity and the socio-economic repercussions of change to the delta have been ignored until recently and as a result very little scientific information was available on this critical wetland area.

The Slave River Delta was once an important link in the transportation routes followed by the early fur trade. Sparse mention of the area was infrequently recorded in the diaries and journals of the early traders and explorers (Ross 1861, Fidler 1934). Scientific interest in the North after the turn of the century resulted in a few minor references to the area in expedition reports. These expeditions, consisting of a few geological surveys, botanical collections and cursory bird and mammal surveys, were usually concerned with other regions and were merely passing through the delta (Cameron 1922; Harper 1931; Law 1950; and Soper 1952a, 1951b, 1957).

The establishment of the Slave River Preserve consisting of the delta and part of the adjacent Slave River Lowlands in 1923, subsequent to the passing of the Migratory Birds Conventions Act of 1917, did little to expand the knowledge of the area. The Preserve was set up for exclusive native hunting and trapping, and little scientific research was done in the area up to 1955 when it was abolished (Hunt 1976).

The lack of baseline information for the Slave River Delta and the whole Mackenzie River Basin was made glaringly apparent when the Peace River was damned at Portage Mountain. The resulting ecological and socio-economic repercussions downstream and in particular, in the Peace-Athabasca Delta, focused public and scientific attention on the importance of baseline information in understanding the importance of the hydrologic regime to northern aquatic and semi-aquatic ecosystems. The Mackenzie River Basin Committee was established to identify and coordinate the programs and procedures for proper management of the river basin. An initial step in the development of the system was to identify critical areas within the Mackenzie Drainage where serious information deficiences existed and to fund the necessary research to eliminate baseline deficiences.

At the same time interest in the hydroelectric potential of the Slave River Rapids near Fort Smith underlined the urgency in collecting the necessary baseline information on the Slave River and Delta to ensure protection of its ecological well-being. Prior to the initiating of the Slave River Delta Study, a number of preliminary studies on the delta's environment and resource utilization were conducted to determine critical areas of future research (Gill et al. 1977; English 1979; and Bodden 1981).

In 1978, the Mackenzie River Basin Committee established a three-year multi-disciplinary research project to obtain baseline information concerning the potential importance and sensitivity of the biological resources of the Slave River Delta. The original research project had four components; hydrology, fish, waterfowl, and aquatic furbearers but was expanded to include an interpretation of the physical development of the delta.

The objectives of the project were as follows:

1. to determine the historical development of the delta, the rate of change and the stability of the distributary channels;

2. analyse and describe the processes that are controlling change in the delta and isolate the factors maintaining its high productivity;

3. map the depositional environments and types of sediment within the Slave River Lowlands;

4. determine the status, distribution of flows and fluctuations of water within the main channels and some of the smaller distributary channels;

5. determine the suspended sediment loads of the Slave River within the delta and document the baseline water quality conditions;

6. compile a complete list of the species of fish, benthic macroinvertebrates and waterfowl found in the study area and provide baseline information on their life histories, relative status, and importance in relation to existing conditions so that post-development evaluations can be made;

7. gather baseline information on the distribution, abundance, and population dynamics of the aquatic furbearers of the delta;

8. provide baseline data on the physical and biological characteristics affecting habitat use and selection by the delta's biological resources;

9. determine the local, regional, and national significance of the fish, benthic, waterfowl and aquatic furbearer populations of the delta and how they would be affected by altered hydrologic regimes; and

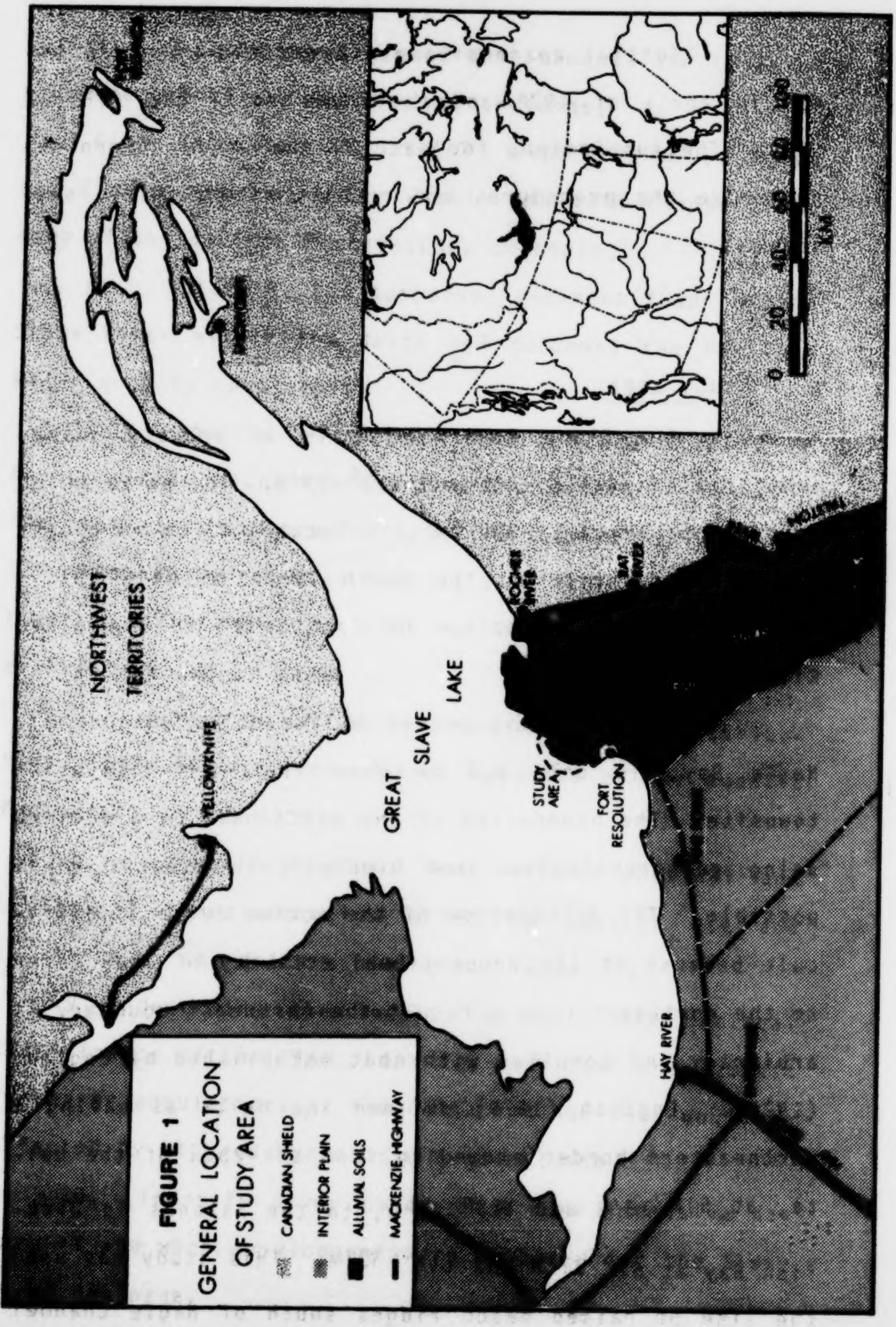
10. identify study needs of a more intensive nature if and when developments are proposed for the Slave River Drainage.

Initial reconnaissance and field research began in April of 1978 and continued until the fall of 1980. The submissions for each of the study components summarize the procedures and results of the field seasons.

B. STUDY AREA

The Slave River Delta is an arcuate shaped area located at 61° 15'N and 113° 30'W. The delta which covers approximately 300 km^2, is located 13 km northeast of Fort Resolution on the south shore of Great Slave Lake and 200 km downstream of Fort Smith on the Slave River (Figure 1).

The southwest corner of the delta (Figure 2), Nagle Bay, is only 2.4 km from the Fort Resolution townsite. The boundaries of the delta have been defined using geomorphological and biophysical criteria where possible. The delineation of the active delta is difficult because of the depositional activity of Jean River to the northeast. As a result the northeast boundary is arbitrary and complies with that established by English (1979). English (1979) defined the delta as having a northeastern border extending from the apex of the delta, at 61° 15'N and 113° 30'W, to the islands in Jackfish Bay at 61° 21'N and 113° 33'W. This study has used the line of raised beach ridges south of Nagle Channel



NORTHWEST TERRITORIES
GREAT SLAVE LAKE
YELLOWKNIFE
STUDY AREA
FORT RESOLUTION
HAY RIVER
ROCHER RIVER
RAT RIVER
TALTSON
0 20 40 60 80 100
KM
CANADIAN SHIELD
INTERIOR PLAIN
ALLUVIAL SOILS
MACKENZIE HIGHWAY

FIGURE 1
GENERAL LOCATION OF STUDY AREA

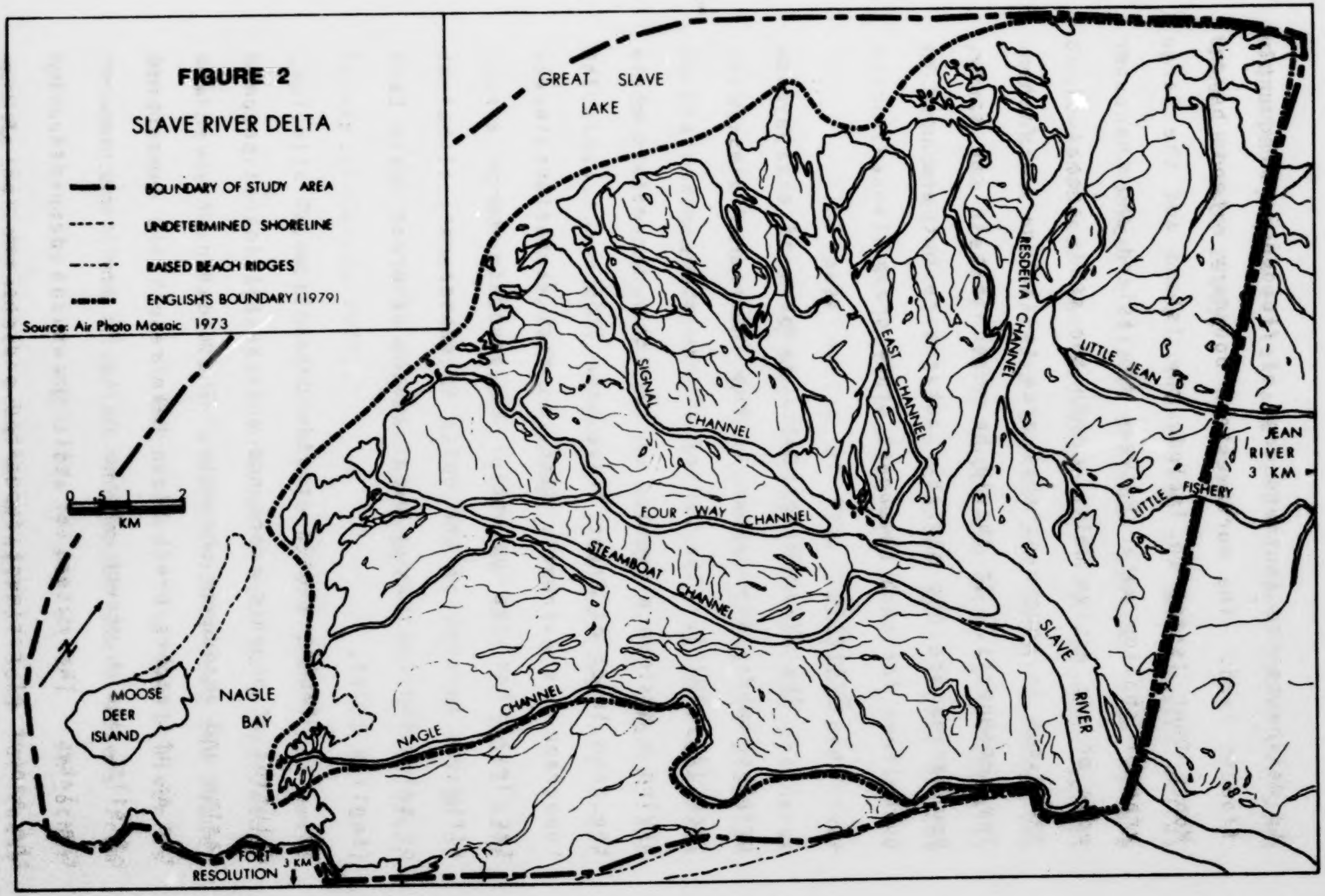


FIGURE 2

SLAVE RIVER DELTA

BOUNDARY OF STUDY AREA
UNDETERMINED SHORELINE
RAISED BEACH RIDGES
ENGLISH'S BOUNDARY (1979)
GREAT SLAVE LAKE
SIGNAL CHANNEL
EAST CHANNEL
RESDELTA CHANNEL
LITTLE JEAN
JEAN RIVER 3 KM
LITTLE FISHERY
FOUR - WAY CHANNEL
STEAMBOAT CHANNEL
SLAVE RIVER
NAGLE CHANNEL
NAGLE BAY
MOOSE DEER ISLAND
FORT RESOLUTION 3 KM
0 .5 1 2
KM

Source: Air Photo Mosaic 1973

to delineate the southern edge of flooded or frequently flooded land. The northwestern boundary extends beyond Moose Deer Island to include the island and the large area of shallow water between the island and the outer edge of the active delta within the study area. It is necessary to encompass this area to include the fisheries components. It should be noted that in the study, boundaries are not strictly adhered to but are used as guidelines for each component study group.

1. Drainage

The Slave River Delta is part of the physiographic subdivision known as the Interior Plains Province (Day 1972). The relief of the study area is low, having a maximum elevation of less than ten meters above the base level of Great Slave Lake (156 m.a.s.l.). The topography is extremely flat, so that variations in water level has the potential to inundate large areas. Fifty-one percent of the delta is submergent, either at or below the low summer water levels of Great Slave Lake (English 1979).

Spring floods provide deposition of alluvium, dilution of organic compounds and the filling of perched basins and abandoned channels. The slowing of river water as it reaches Great Slave Lake results in deposition of silt, and a growth of the delta in the direction of the lake. The extent of this growth is determined by the amount of sediment deposited and the erosion of the deposits by wave action and lake currents (Reid and Wood 1976, Bardach 1964).

The delta differs from the other major deltas in the Mackenzie River drainage system, such as the Peace-Athabasca and Mackenzie in that meander scroll depressions, interlevee basins and perched lakes are rare. The areas of still water are made up principally of abandoned distributaries created by shifting of the major channels during flood stage.

The peak period of flow in the Slave River occurs soon after spring breakup with minimum discharge in winter. Some of the Slave River's flow is diverted to the northeast through Jean River. The main channels of the delta are Nagle, Steamboat, East, Signal, and ResDelta. The main volume of flow empties into Great Slave Lake from ResDelta Channel.

Annual discharges over the past 17 years have varied from a minimum of 2450 m^3/s in 1970 to a high of 4560 m^3/s in 1973 and have averaged 3330 m^3/s (Water Survey of Canada 1977).

Flood stages in the delta are lower than would be expected because Lake Athabasca acts as a regulatory device on the Slave River's main tributaries, the Peace, Athabasca, and Fond du Lac rivers. The Peace River is renamed the Slave River at the point where waters from Lake Athabasca join with the Peace River. In other words, Lake Athabasca acts as a natural sump for these river's discharges. Prior to the construction of the Bennett Dam on the Peace River at Portage Mountain, the level of the Peace River in the three week period of spring flood was higher than that of Lake Athabasca. Flood waters of the Peace River flowed down the gradient into Lake Athabasca, reversing the normal flow. Flood waters entered the lake through Riviere des Rochers, Revillon Coupe, and Chenal des Quatre Fourches (Geen 1974, Howell 1978). The large surface area of Lake Athabasca can accomodate the large inflow of water with an annual water level fluctuation of 1.7 m (Peace-Athabasca Delta Project 1972). The W.A.C. Bennett Dam regulates the flow of the Peace, removing the large flood peak (Howell 1978).

3. Climate

Climatic conditions for the Slave River Delta are recorded at the meteorological station at Fort Resolution Airport. Although the location of meteorological data collection has varied during the past 30 years, the difference in the locations of meteorological stations has been minimal and should not affect the quality of the recorded data (Table 1).

The climate of the south shore of Great Slave Lake can be classified as Continental Subarctic, Dfc according to the Koppen-Geiger classification (Strahler 1976). The winters are long, cold and severe, of approximately eight months duration and the short, warm

TABLE I

CLIMATIC CONDITIONS (FORT RESOLUTION)

Mean Annual Mean Monthly Temperatures (Degrees Celsius)

	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	ANN
1974 (ACTUAL)	-22.2	-25.0	-21.7	-3.9	5.6	13.9	15.0	12.8	5.6	-2.2	-7.2	-17.8	-4.4
30 YEAR AVERAGE	-26.1	-23.8	-16.7	-5.6	5.0	11.7	15.6	14.4	7.8	0.6	-11.1	-21.1	-3.9

Monthly & Annual Total Precipitation (mm.) & Snowfall (cm.)

	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	ANN	SNOW
1974 (ACTUAL)	2.79	2.46	2.82	.20	1.78	4.67	9.06	3.70	4.59	3.15	3.20	3.73	41.73	246.66
30 YEAR AVERAGE	1.45	1.36	1.20	1.20	1.57	2.50	3.55	3.30	3.81	3.37	4.37	1.98	29.57	153.92

1974 Temperature Extremes, Monthly & Absolute Temperatures (Degrees Celsius)

	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	AB
MAXIMUM	-5.6	-2.2	-1.1	12.2	22.8	27.2	26.7	28.9	20.6	6.1	6.7	-0.6	33.3
MINIMUM	-51.1	-42.8	-40.5	-30.0	-15.0	-2.2	1.7	-2.2	-4.4	-13.3	-20.0	-33.4	-52.8

0° C FROST	mean date (last) spring	June 3
	(first) fall	Sept 14
	frost free period days	103
	degree days	1510
5.6° C GROWING SEASON	beginning	May 17
	end	Sept 24
	duration	130
	degree days	1657

Source: Environment Canada, Climate of Alberta, with data for Yukon and Northwest Territories, 1977.

summers are frost-free for only some 100 days (Burns 1973). Great Slave Lake influences the climatic conditions, having an ameliorating effect. Summer and winter temperatures are not as severe, therefore, as those of inland locations.

Approximately half of the precipitation is rain and half is snow (Environment Canada 1977). The 30-year annual average is not sufficient to prevent a moisture deficit in most years. Rainfall occurs between May and September with the maximum in September. Most of the precipitation is from local convection. During this time period the region is influenced by cool, moist Pacific air and the maritime Polar air mass. Maximum precipitation occurs in November, with a 30-year mean of 4.37 cm., most of which is snow. Winter is dominated by the Mackenzie high pressure system of the Arctic air mass. Minimum precipitation occurs in March and April, 1.20 cm being the 30 year mean.

Spring breakup also plays an important role in modifying the climate of the delta. Spring breakup on the river usually occurs in mid-May but leads of open water appear in April. The resulting decrease in surface albedo of the delta results the study area to be warmer than the surrounding land and water areas during the spring (Hare and Ritchie 1972, Gill 1975, and Environment Canada 1977). Freezeup of the delta occurs in late October coinciding with continuous snow cover.

4. Glaciation, Soils, and Permafrost

The study area was glaciated by the Laurentide ice sheet. Moose Deer and Round islands, located at the outer edge of the delta, are roches moutonnees (Cameron 1922) and provide good evidence of past glaciation. During the early Halocene, the glacial ice retreated and a large ice marginal lake, Lake McConnell, was formed in the isostatic depression between Great Slave Lake and Lake Athabasca (Craig 1965). Evidence of the extent of this glacial lake can be found in stranded beach lines south of Nagle Channel and in lacustrine deposits (Radojicic 1967).

The soils of the delta are formed from post glacial alluvial deposits, distinguishing them from archean granites and gneiss to the north and east and the paleozoic gypsum and breccia to the west (Day 1972). The Cumulic Regosols are composed of brownish grey and calcareous loamy sand to silty clay loam. These soils occur in silt bars and siltflats of the delta and are well to poorly drained. They are usually less than three meters above average river level and are frequently flooded. Cryic Cumulic Regosols are found in more stable, moderately well-drained areas, and have a thin organic layer over calcareous loam. Areas of the delta rarely flooded have developed Orthic Hemic Gleysols.

The study area is within the discontinuous permafrost zone defined by Brown (1960,1974). Day (1972) found permafrost to be associated with the white spruce assemblages of the delta. The distribution of permafrost is more extensive than previously expected though, because it has been found in sedge tussock communities (Gill 1976, English 1979).

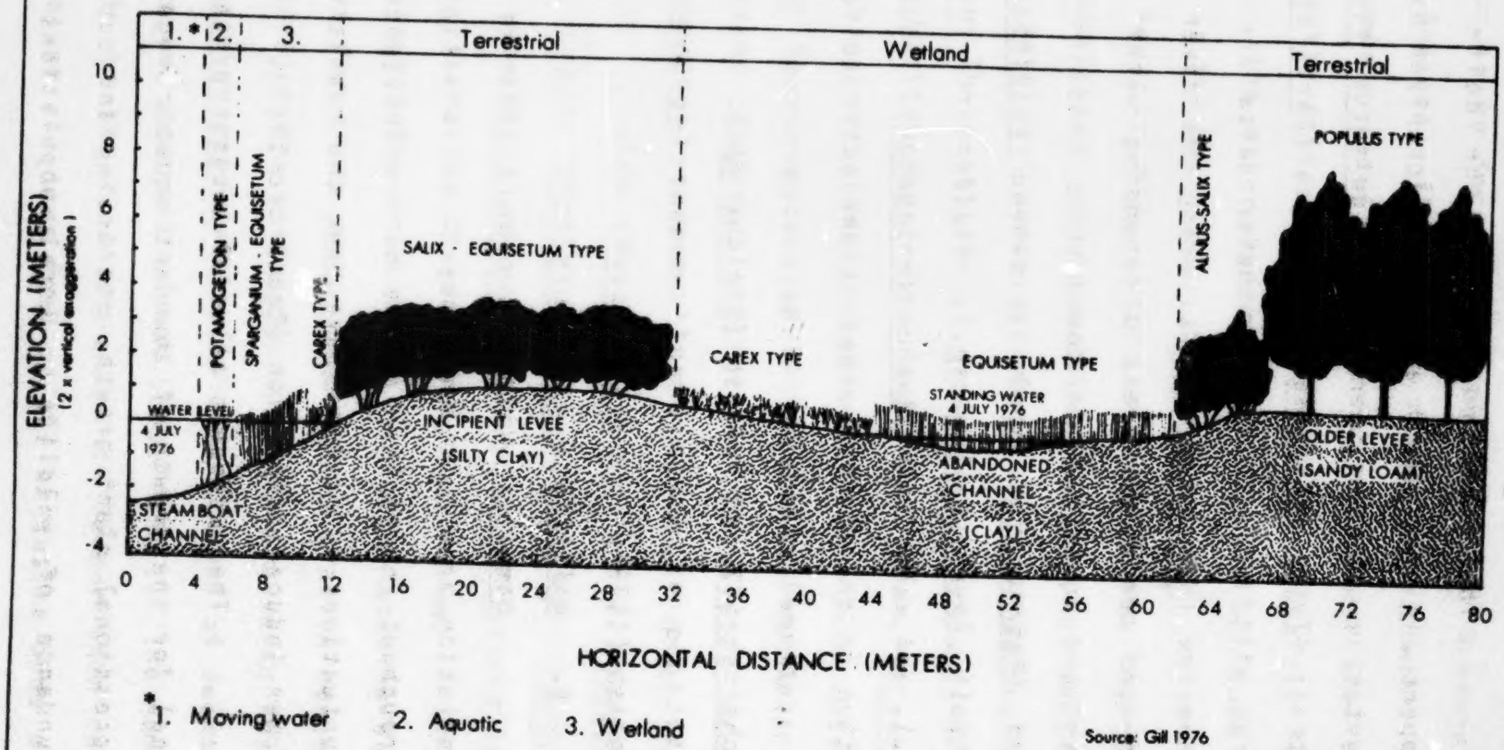
5. Vegetation

The forest of the Slave River Lowlands and Fort Resolution area is classified as Forest Region B.23a, Upper MacKenzie Boreal Forest (Rowe 1972). The Slave River Delta and Lowlands are distinguished from the surrounding area by the dominant coniferous species, white spruce (*Picea glauca*), which is restricted to well drained, higher, seldom flooded alluvial soils. Rowe (1972) and Day (1972) identified large areas of white spruce and balsam poplar (*Populus balsamifera*) on the river's alluvial flats. Areas around the Slave River are characterized by black spruce (*Picea marina*) and jackpine (*Pinus banksiana*) (Raup 1946, Harper 1931).

The general successional profile developed by Gill (1976) demonstrated the effect of flood frequency on vegetation (Figure 3). Mineral soil deposition during the spring flood provides nutrients for a wealth of perennial herbs, grasses, and equisetum in the wetlands. In the better drained, less frequently flooded sites, beyond the ice scour zone, colonization is a progression of willow (*Salix spp.*), alder (*Alnus spp.*) and balsam

FIGURE 3

VEGETATION ZONATION ALONG STEAMBOAT CHANNEL


1. * 2. 3.
Terrestrial
Wetland
Terrestrial
ELEVATION (METERS)
(2 x vertical exaggeration)
10
8
6
4
2
0
-2
-4
POTAMOGETON TYPE
SPARGANIUM - EQUISETUM TYPE
CAREX TYPE
SALIX - EQUISETUM TYPE
CAREX TYPE
EQUISETUM TYPE
ALNUS-SALIX TYPE
POPULUS TYPE
WATER LEVEL 4 JULY 1976
STANDING WATER 4 JULY 1976
INCIPIENT LEVEE (SILTY CLAY)
ABANDONED CHANNEL (CLAY)
OLDER LEVEE (SANDY LOAM)
STEAMBOAT CHANNEL
0
4
8
12
16
20
24
28
32
36
40
44
48
52
56
60
64
68
72
76
80
HORIZONTAL DISTANCE (METERS)
*1. Moving water
2. Aquatic
3. Wetland

Source: Gill 1976

poplar (English 1979).

The outer portion of the delta does not support any tree growth and is characterized by riparian vegetation such as horsetail (*Equisetum fluviatile*), cattail (*Typha latifolia*) and sedges (*Carex spp*.). The large silt/mud flats of the outer delta are much more extensive than those located along the river channels. Isolated ponds and areas of standing water have well developed aquatic plant communities consisting of pond weed (*Potamogeton spp*.), arrowhead (*Sagittaria sp*.), milfoil (*Myriophyllum sp*.), bladderwort (*Utricularia* sp.), and water lily (*Nuphar variegatum*). Aquatic vegetation in the shallow areas of the outer delta consists of scattered stands of Richardson pondweed (*Potmageton richardsonii*) and bulrush (*Scripus sp*.). Detailed descriptions of delta plant communities are given in English (1979).

6. Wildlife

Mammals: Wildlife populations in the Fort Resolution area have been subject to variations in size throughout the history of the native settlement. These fluctuations in numbers have been the result of natural or man induced regulation (Radojicic 1967).

The eutrophic alluvial habitat of the delta is ideal for the growth of abundant aquatic vegetation and successional plant growth, attracting and supporting an abundance of wildlife. Local populations of moose

(Alces alces) have fluctuated in numbers historically but appear to be increasing (G.H.T.R. 1976, Novakowski 1967). Seasonal fluctuations also exist, with the largest numbers found in the spring and summer when the islands of the delta offer the year's young safety from predation. The other large mammal frequently found in the delta is the black bear (Ursus americanus).

Aquatic fur-bearers represent the largest mammal population in the delta, with the muskrat (Ondatra zibethicus) being extremely abundant during the peak years. The multitude of sloughs and waterways provide ideal habitat for shelter and food. Beaver (Castor canadensis) are relatively abundant in the main waterways. The dense vegetation growth of the delta also supports large cyclical populations of varying hares (Lepus americanus) and small microtines. Other fur bearers such as mink (Mustela vison), marten (Martes americana) Ermine (Mustela erminea), fisher (Martes pennanti), Lynx (Lynx canadensis) and red or colored fox (Vulpes fulva) are also found in the study area.

Birds: The Slave Delta is a prime staging and resting area for three major waterfowl migration routes (Bellrose 1976). The early open water and exposed food supply (Equisetum spp.) attracts large numbers of ducks, geese, swans and sandhill cranes (Soper 1957). The number of birds in the fall migration is larger than the spring migration and they feed on the extensive beds of

Potamogeton growing in the outer delta. The rich riparian and aquatic habitats also supports a population of nesting fowl, although the number is substantially smaller than the transient population (Soper 1957).

Fish: The muddy, turbid waters of the Slave River Delta support a large number of fish species because of the nutrients carried out into the colder waters of Great Slave Lake by the plume of the Slave River (Rawson 1950). Cisco (*Coregonus spp.*) are abundant in the delta area, especially from mid-September during their spawning runs which coincides with lake whitefish (*Coregonus clupeaformis*) (McPhail and Lindsey 1975). Large numbers of burbot (*Lota lota*) are found in the back eddies and channels of the delta in November and December. Inconnu (*Stenodus leucidhthys* mackenzi), the largest fish found in the study area, follow a similar spawning timetable as lake whitefish. Northern pike (*Esox lucius*) are abundant during their spawn after spring break-up. Large numbers of longnose suckers (*Catostomus catostomus*) can be found in the outer delta fringes. The calmer, quieter backwaters are home for the goldeye (*Hiodon alesoides*), walleye pickeral (*Stizostedion vitreum*) and a number of small prey species. Lake trout (*Salvelinus namaycush*) were formerly caught off the edge of the Slave River sediment plume but have been extremely rare for the past decade.

7. *Fort Resolution*

In 1786, Cuthbert Grant of the Northwest Company and his rival, Laurent Laroux, of the McLeod and Company, established posts in the Slave River Delta, the earliest settlements in the Northwest Territories. A Hudson's Bay post established in 1815 on Moose Deer Island was renamed Fort Resolution in 1819. In 1821 the Hudson's Bay Company relocated to the present site in Fort Resolution. The settlement developed as a transportation and commercial center based on river barge traffic and the fur trade. With the reduction in fur trade and the development of road (1948), air (1955), and rail (1964) linkages from the south to Hay River, west of Fort Resolution, the economic and transportation importance of the community declined.

Present day Fort Resolution does not appear to have any one ethnic group dominating the social structure of the community. The total population appears stable at approximately 500 people, of which approximately 50 percent are Metis and 40 percent are Treaty Indians, (Chipewyans) (Treaty Number 8). The settlement participates heavily in the harvest of natural resources, particularly those of the Slave River Delta (Bodden 1981). Other economic activities and employment opportunities within the settlement include the Slave River Sawmill, territorial and local government and small private service industries.

The townsite of Fort Resolution forms a double crescent centered on the government wharf and around the gentle sloping shores of Resolution Bay. Resolution Bay offers a relatively sheltered harbour from the prevailing winds and waves of Great Slave Lake. Government and private housing is in a grid system on an alluvial flat back from the raised lake shoreline. Town roads are of gravel construction and the main highway connects the town with Pine Point 65 km. to the west, the federal airport one km. to the north and the Slave Delta to the east.

The main facilities within the settlement include; a water treatment plant, elementary school, laundry, old folk's home, health clinic, territorial government offices, settlement office, and the diesel-electric generation plant run by the Northern Canada Power Commission. As of 1971, a small minority of the houses (less than 10%) had running water and indoor toilets (Grainge 1971). The situation has changed little since then with only the government buildings having running water or septic sewage systems. The town's drinking water supply is produced at the water treatment plant near the lake and trucked to individual houses daily.

DEPARTMENT OF INDIAN AFFAIRS
AND NORTHERN DEVELOPMENT

Northern Affairs Program, Water Resources Division
Yellowknife

A Slave River Delta Interpretative Explanation

Prepared by

J.D. Mollard and Associates
in association with
C.R. Neil, P. Eng.

Northwest Hydraulic Consultants Ltd.
Edmonton, Alberta

Regina, Saskatchewan

February, 1981

EXECUTIVE SUMMARY

Eight sets of black and white panchromatic aerial photographs and 1 set of colour aerial photographs, taken over the interval 1930 to 1979, and 5 Landsat images, taken between 1972 and 1980, have been interpreted and compared in mapping the Slave Delta and changes in it. The airphotos and satellite imagery cover the active and inactive portions of the modern Slave River Delta and, in certain sets, extend southward to show the Slave River alluvial floodplain above the Delta. In addition, several maps and reports were obtained,and pertinent data relating to the study were extracted.

The analysis and interpretation of all these sources of information reveal the historic development of the Delta, its rate of change, and the stability of the delta distributaries. Briefly, the Delta has been advancing over the past several millennia. The Delta has prograded alternately on the west and east sides of the Slave River while the shoreline on the opposite side of the Slave River has been more or less stationary or retreating. The shoreline of the active Delta is advancing, on average, at a rate of about 1½ km per 50 years (1930 to 1979), or 3 km per century. The rate of advance is not uniform over time, however. Instead the advance appears to be jerky, with intervals of rapid advance separated by intervals of little or no advance or even shore erosion.

Factors controlling change and the vitality of life in the delta appear to be related largely to Delta hydrology and sedimentation, in particular inundations by annual flood waters carrying nutrient-rich sediments that replenish water and deposit fresh sediment in sloughs and marshes within the Delta Complex. Relatively limited statistical data are available, however, on flood level fluctuations, sediment load, and water quality within the Slave Delta itself. Over the past half century, the flows in distributary channels appear to have decreased in the area west of Old Steamboat Channel and increased in Resdelta Channel, which now takes 86% of the Slave River flow during the summer months. Obvious changes in Resdelta Channel width reflect changes in increased flow. Also, changes in the location and pattern of emergent vegetation in the nearshore zone accompany changes in nearshore hydrography and Delta aggradation. As a result, the locations of emergent vegetation used by wildlife also change significantly over a period of several decades.

A main part of the study was devoted to mapping the geomorphology of the entire Slave River Lowland north of Fort Smith, including the active and inactive portions of the modern Slave Delta. This map information is shown in Figures 17 and 18.

Postglacial isostatic rebound and long-term Delta progradation appear to be largely responsible for the very low gradient on the Slave River north of Fort Smith.

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CHAPTER 1

INTRODUCTION

1.1 Terms of Reference

The terms of reference of the Slave Delta interpretation project covered in this report are set out in a letter dated September 11, 1980, from Jack T. Cole, P.Eng., Science Procurement Manager, Science Centre, Department of Supply and Service, Ottawa, as follows:

"1. Analyse and interpret the available aerial photographs and hydrologic and sediment data to determine the historic development of the Delta, the Delta's present rate of change (growing, shrinking or stable), and the stability of distributary channels and status of the water in the Delta (increasing, decreasing, or stable).

"2. Analyse and describe the processes controlling change in the Delta (spring flood, ice jams, sediment load, characteristics of Great Slave Lake) and what factors are maintaining the Delta in a disclimax stage (high productivity).

"3. Submit a final report on the results of the above work. The report will provide a detailed narrative explanation of findings supported by appropriate maps. The report will contain an executive summary at the beginning and conclude with a synthesis which will describe the interrelationships between the various parts of the study."

1.2 Components of the Study

In order to understand the postglacial development of the Slave Delta, and changes in the Delta, it is necessary to interpret the depositional environment and history of the entire Slave River Lowland, including the modern Delta composed of active and inactive parts. Accordingly, a major component of the present study entailed the mapping of depositional environments and of the different types of sediment within the Slave River Lowland. Emphasis has been placed on the history of postglacial alluvial and deltaic sedimentation and erosion, and changes in the active delta related to stability of its main distributary channels.

In addition to an explanation of the postglacial geomorphic history of the Slave River Lowland, including the Slave Delta at its northern extremity, data on Slave River hydrology and sedimentation have been analyzed and interpreted.

1.3 Geological Setting

Physiographically, the Slave River Lowland lies on the eastern side of the Great Slave Plain Division of the Interior Plains Region (Figure 1). The Slave Delta is located at the terminus of the Slave River, where it discharges into Great Slave Lake. The modern Slave Delta is situated at the downstream end of the Slave River Lowland, which is a long and narrow alluvial-lacustrine plain that extends from the Little Buffalo River on the west to the Talston River on the east.

The Slave River Lowland is underlain by Middle Devonian rocks (map unit 9 in Figure 2). The sedimentary rocks consist mainly of gypsum, salt, limestone, and breccia in their basal strata, and of dolomite and limestone in their upper strata. Scattered bedrock hills appear in the Lowland, and these consist of carbonate rock at or very near the surface. To the east, Archean rocks of the Shield Region (Figure 1) are mainly granitic and granitic gneiss rocks (map unit 4, Figure 2).

Surficial deposits consist mostly of fine sand and finer-grained sediments of alluvial, deltaic, and lacustrine origin. They are generally thin and overlie late glacial and early postglacial deposits carried into glacial Lake McConnell (Figure 3).

1.4 Climatic Setting

Data on daily mean, maximum, and minimum temperatures, total precipitation and rainfall are given for Fort Smith, Fort Resolution and Hay River recording stations in Table 1 for the period 1931 to 1960. An exception is the daily mean temperature for Fort Resolution, which is given for the 22-year period from 1931 to 1960.

Total annual precipitation is low at all stations. Annual snowfall is about 47.5 inches. Fort Smith has a shorter and cooler frost-free season than Fort Resolution, but a longer and warmer growing season. The long frost-free season at Fort Resolution and Hay River is due to the influence of Great Slave Lake in autumn.

CHAPTER 2

SOURCES OF DATA

2.1 Aerial Photography

Nine sets of aerial photographs were obtained from the National Air Photo Library in Ottawa. They cover all or parts of the modern delta of the Slave River and the lower part of the Slave River Lowland above the modern delta. Some of the sets of airphotos cover more than 4000 km^2. All of the photography is black and white panchromatic except one set of normal colour photographs that were taken in August 1966.

Following are the date and scales of the airphotos:

Date	Scale
August 1930	1:12,000
July 1946	1:25,000
August 1954	1:70,000
September 1957	1:25,000
July 1960	1:40,000
August 1966	1:24,000
September 1970	1:60,000
August 1972	1:8,000
July 1973	1:25,000
July 1979	1:20,000

2.2 Satellite Imagery

The following Landsat imagery was obtained and examined:

Date	Image number	Type of image	Band(s)
Oct 20/73	E 1436-18145	Colour composite 8	4,5,7
Aug 18/75	E 11121-17562	Colour composite 8	4,5,7
July 31/80	E 22017-18094	Colour composite 8	4,5,7
July 31/80	E 22017-18094	Colour composite 9	5,6,7
Sept 20/72	E 1059-18215	B & W print	5

In order to show suspended sediment concentrations off the mouth of the Slave River, and along the Great Slave Lake shore to the east and west, 35-mm slides were made of two colour composite Landsat images: August 1975, and July 1980. A density sliced image was also produced from Landsat band 5 image acquired on August 18, 1975. A digitally (computer) processed image was prepared from colour composite 9 (image acquired July 31, 1980). This latter image shows suspended sediment in the Slave River and adjoining Great Slave Lake. A second digitally processed false colour image was produced from colour composite 9 (acquired July 31,1980) to show vegetation in the lower Slave River Lowland and the nearby Precambrian Shield to east. Altogether five 35-mm slides were made and all were delivered to Mr. Gordon Lewis, Environment Canada, on January 30, 1981.

2.3 Other Main Sources of Data

Other main sources of data relate to the following soils, geological, hydrologic,and sedimentation maps or reports:

Craig, B. G.

1965 Glacial Lake McConnell and the Surficial Geology of Parts of Slave River and Redstone Map-Areas, District of Mackenzie. Geol. Sur. Can. Bull. 122.

Davies, K.F.

1981 Slave River Delta Hydrology Study. Prepared for Mackenzie River Basin Task Force, Inland Waters Directorate, Western and Northern Region, Environment Canada, February.

Day, J. H.

1972 Soils of The Slave River Lowland in the Northwest Territories. Soil Research Institute, Central Experimental Farm, Canada Department of Agriculture, Ottawa.

Environment Canada

1975 Waves Recorded Off Hay River, N.W.T., June 18, 1975 to September 30, 1975. Data compiled by Marine Envir. Data Service, Ottawa.

Environment Canada

1980 Slave River Delta Hydrology Study. Interim Report from Water Survey of Canada, Calgary to Mackenzie Basin Task Force.

Hydrological Atlas of Canada

1978 Published by Government of Canada, Ottawa.

Noble, P., and Comfort, G.

1980 Pipeline damage by ice ridges. Paper submitted to the NRC Workshop on Ice Ridging, Calgary.

Northwest Hydraulic Consultants Ltd.

1980 Slave River Hydro Feasibility Study. Sponsored by the Alberta Environment, Edmonton.

CHAPTER 3

GENERAL DISCUSSION OF DELTA CHARACTERISTICS

This section deals with the general framework of deltas, and includes a discussion of characteristic delta types, processes, and sediments. The information presented is a digest of material extracted from several papers and books containing data on delta formation and behaviour. A literature review was made before the detailed examination of the Landsat imagery and the stereoscopic study of the black and white panchromatic photography. However, most of the data contained in this section,and the illustrations used,were extracted after completion of map and airphoto interpretation, so that the information would be relevant to the Slave Delta setting.

3.1 Delta Types

There are three basic types of deltas (Figure 4), and examples of all three are found in the Mackenzie River basin (Figure 5). They are referred to as a) arcuate, of which the Slave Delta is a stunted variety, i.e. a delta along which part or all of the shoreline has been or is being modified by waves and longshore currents; b) birdsfoot, or digitate, of which the Peace and Athabasca Deltas are classic representatives; and c) estuarine, of which the Mackenzie Delta is the best example in Canada.

The eastern, older portion of the Slave Delta (Figure 6) is a stunted arcuate type; here the Delta has been blunted and smoothed by wave action and longshore currents. The active western part is characteristic of a little-modified arcuate delta. In this area the Slave Delta contains 11 principal distributary channels,indicated in Figure 7.

3.2 Delta Processes

The processes that accompany delta formation are visualized best by means of annotated diagrams. A good example is Figure 8. As seen in this figure, delta sediments build outward into a lake or into the sea on both sides of a distributary channel. The flow from distributaries resembles the expansion of submerged jets. Shoals built at the mouth of distributaries commonly advance as indicated in Figures 8, 9, and 10. The three diagrams on the left in Figure 8 represent the present situation at the mouth of Sawmill Channel in Nagle Bay (Figures 6, 7), where a subdelta has formed.

The processes shown in the middle and right diagrams of Figure 8 are well illustrated on the airphotos taken September 26, 1970 -- particularly at and between the mouths of Old Steamboat Channel and Resdelta Channel.

The geometry of deltas built into lakes is determined by interaction between fluvial and lacustrine processes. The active delta may be divided into two parts: an intradelta part, and a prodelta part. The intradelta part consists of a complex of distributary channels, natural levees bordering these channels, crevasse splays, and interdistributary basins consisting of swamps, marshes, bays, lagoons, and sloughs. In most modern deltas the proportions of the subaerial intradelta area occupied by distributary channels, levees and splays, and interdistributary floodbasins are roughly 5%, 25%, and 70% respectively. Distributary channels are characteristically serpentine. These channels occur widely over both the active and inactive parts of the subaerial deltaic plain.

Shoreline configuration is determined largely by the relative importance of river deposition,on the one hand,and wave and current erosion on the other. A break in offshore delta slope often occurs at depths equal to the effective depth of wave erosion, commonly about 10 m in the ocean and large deep lakes and much less in sheltered bays. In shoal lakes a break in slope usually occurs at quite shallow depths. This break in slope marks the delta front.

The counterpart of subaerial delta deposition is subaqueous deposition, which results in the formation of topset beds, foreset beds (extending outward and dipping downward in inclined, parallel strata), and bottomset beds, extending beyond the delta front and consisting largely of soft prodelta clays. Topset beds are usually coarser than foreset beds, and bottomset sediments are finest of all.

Rate of delta front advance depends on several variables. The effects of these variables on slow versus fast growth are given qualitatively in Table 2, and a further description of how these factors operate is given in Table 3. The correlations suggested in Table 2 are helpful to the photointerpreter assessing changes in the delta front stability since the variables mentioned are often expressed on aerial photographs -- especially comparative airphotos taken at intervals over a period of several decades.

The rate of delta growth is slow (the shoreline may even erode and recede) in high wave and current energy environments, especially if lake levels happen to rise sharply for any reason. Shore erosion is usually caused by intense storms that are generally only a few days in duration. Storms move water onshore and increase the local lake level, a phenomenon referred to as wave set-up (or wind tide).

The appearance of barrier bars, clearly seen in the 1970 airphotos of the Slave Delta, can also be an important factor influencing rates of shore erosion locally.

Rate of delta advance is slower where the offshore gradient is high,or where the inflowing sediment happens to be filling a large, deep nearshore basin. It can also be slow in places where the lake bottom is actively subsiding through the compaction of soft underconsolidated clays (Figures 10 and 11), or through crustal downwarping. In addition, low rates of sediment influx, small content of sand in the inflowing sediment, and low rates of vegetation growth are all associated with slow delta front advance. A rapidly advancing shoreline on the other hand may be expected in places where there is a large supply of sandy sediment, and in places of active land emergence, as in regions of rapid postglacial isostatic rebound. Parts of a delta that have been cut off from active river sedimentation or that are experiencing rapid crustal subsidence may erode and retreat.

3.3 Delta and Fluvial Sediments and Forms

There is continuous transport and redeposition of particles in turbulent moving water. The finer particles of sand, silt, and clay are transported in suspension, with coarser sand and larger particles carried along stream bottoms. Where the current velocity decreases the transport capacity also decreases, and some of the sediment load is deposited. At river mouths, where a stream enters a large body of still water, usually there is a rapid decrease in current velocity. Where the suspended sediment is nearly all silt and clay it often spreads over a large area of the lake before being deposited. This is evident in Landsat images of the Slave River delta (see the five 35 mm slides that accompanied the letter to Gordon Lewis dated January 30, 1980).

With initial deposition of bed load material, a bar develops in front of the river mouth (Figures 8, 9 and 10). With continued deposition, an island is formed separating two river distributaries.

Stream patterns in deltaic environments are greatly affected by lacustrine and marine processes, and can differ from patterns formed on broad floodplains, such as occurs between the active Slave Delta and Fort Smith. Schematic diagrams illustrating the types of landforms and deposits occurring on the floodplain north of Fort Smith are shown in Figures 12, 13, 14, 15, and 16. Figure 17 is a map of the landforms and deposits of the Slave River Lowland, extending from Fort Smith at the Alberta/Northwest Territories border to Great Slave Lake. Figure 18 is a larger scale map of the landforms and deposits of the active and inactive Slave Delta and of the downstream portion of the Slave River Lowland.

With the deposition of sediments at the delta front the length of distributary channels increases, resulting in a reduction of slope and transport capacity. Long continued delta aggradation results in partial filling of the channels and in overbank spill, which creates secondary channels. Overbank flooding and deposition are the processes by which the natural levees of a delta develop. In time the levees seal off flow from the parent stream. In this environment, abandoned distributaries, often containing elongate sloughs, are numerous. Where channels are abruptly sealed, further bed load addition is limited and channels may change very little for decades, creating habitat for wildlife and waterfowl.

Continually shifting distributary courses lead to the building of successive subdeltas. A good example is Sawmill Delta in Nagle Bay. As Sawmill Delta protrudes farther and farther into Great Slave Lake, its slope and capacity decrease, and shorter routes are found in nearby bays, marshes and swamps. A new distributary course is initiated, and a new subdelta or crevasse splay begins to form (see Figure 8, lower left diagram).

Processes, environments, and deposits characteristic of active deltas are widespread on the alluvial plain above the present Slave Delta on the Slave River Lowland (Figure 18). Floodbasins (backswamps), natural levees, crevasse splays, and abandoned channels on alluvial floodplains (Figure 17 and Table 4) all have their counterpart in interdistributary bays and marshes, levees, subdeltas, and abandoned distributary channels on deltas (Figure 18); their interpretation helps in understanding how the landscape was formed and how it may be used.

The grain-size distribution and organic content of deposits on floodplains developed on very low gradient rivers like the Slave River are often similar to sediments found in corresponding subenvironments on actively forming large deltas (compare Figures 15 and 16 for rivers and Table 5 for deltas).

In the case of large modern deltas, topset beds are usually absent and foreset slopes are usually poorly developed, if at all. In this report the term "delta front slope" is used for steeper parts of the bottomset slope, and the term "prodelta slope" is used for the lower and gentler parts of bottomset slopes.

CHAPTER 4

GEOMORPHIC PROCESSES AND EVOLUTION OF THE SLAVE RIVER LOWLAND AND SLAVE DELTA

Regional controls affecting the evolution of the Slave River Lowland and Slave Delta are shown in Figure 1 (physiography), Figure 2 (bedrock geology), and Figure 3 (glacial Lake McConnell). Unfortunately, the information contained in these three figures is not detailed enough to permit a proper understanding of significant past depositional environments, which is required to reconstruct the early postglacial and later geomorphic events and to evaluate their significance in the evolution of the lower Slave River floodplain and the Slave Delta. It was therefore found necessary to prepare a map of the geomorphology of the Slave River Lowland north of the Alberta-Northwest Territories border (Figure 17), in which significant depositional environments are emphasized. Figure 18 shows in greater detail the depositional environments, landforms, and surface materials of the Slave Delta and lower Slave River floodplain. This figure also shows internal drainage, permafrost, and vegetation. The detailed legends accompanying Figures 17 and 18 are intended to be self-explanatory.

The following sequence of processes and events has been reconstructed from the interpretation of data shown on Figures 17 and 18 (*see* also the 1:200,000 scale map of Figure 17a, which is contained in the map pocket):

1) The Slave River formed two extensive belts of lateral accretion topography downstream of Fort Smith. The two major belts are located (i) between the north end of the Fort Smith sand delta and about latitude 60°45', and (ii) north of latitude 61°00'.

2) During the draining and lowering of glacial Lake McConnell and the shifting of its shoreline from Fort Smith (latitude 60°, elev. 183 m) northward to latitude 61°,very little development of raised beaches took place, and no major shoreline erosion events are recorded. North of latitude 61°, however, the occurrence of raised beaches become much more common (Figure 17), suggesting episodes of past shore erosion.

3) Belts of multiple beach ridges appear to have developed alternately, first on the east side of the Slave River, and then, some distance downstream, on the west side of the Slave River (see Figure 17). This is a remarkable evolutionary characteristic of the lower Slave River Lowland and modern Slave Delta. West (or east) of each belt of raised sandy beaches, a contemporaneous delta appears to have formed, similar to what is occurring at present between Fort Resolution and the mouth of the Talston River. Two major sequences of beach ridges can be observed east of the Slave River as well as a shore that is presently undergoing wave and current modification. On the west side of the Slave River there are two raised (relict) beach ridge sequences. Abandoned and moribund distributaries on relict deltas appear above each belt of raised sand beaches,and distributaries are truncated by the beach ridges. These events indicate clearly that the delta advance on both sides of the Slave River has been and still is marked by intervals of sedimentation and delta advance followed by wave and current erosion and shoreline retrogression.

4) Spits have formed along a wave-dominated, retrograding coast from Gaudet Bay to Resdelta Channel (Figure 17), while active delta deposition and a prograding coast has formed from Resdelta Channel to Nagle Bay (Figures 26 to 37). However, as the shoreline changes indicated by Figures 26 to 33 disclose, the prograding process in the active delta area has been rather jerky.

5) Large interdistributary open bays form and eventually become closed basins. In time these fill with mineral and organic material and become marshy or swampy.

6) The dominant wind direction forming the sequences of raised beaches north of latitude 61° appears to have been from the west and northwest (note the long westerly and northwesterly fetches associated with the shape of Great Slave Lake).

7) After formation of a belt of beach ridges, a serpentine distributary channel follows a course along the coast and separates the beach ridges from later (younger) deltas constructed lakeward.

8) During the jerky course of delta progradation, small islands of carbonate rock and till represent sources of coarser sediment for the creation of surrounding wave-modified platforms (unit 6, Figure 17b), beach ridges (unit 5), and spits (unit 10). Nearshore shoals appear to be ephermal: grow, then erode and disappear.

9) Where the water in Great Slave Lake is shallow and warm, and is fed by nutrient-rich sediments discharged by the Slave River, emergent (and possibly submergent) vegetation grows -- usually around and between small subdeltas; the latter are then partially protected from storm wave action and from damage by moving ice in spring break-up.

CHAPTER 5

ENVIRONMENTAL FACTORS MODIFYING THE SLAVE DELTA OTHER THAN HYDROLOGY AND SEDIMENTATION

Several factors may affect the changes in delta shorelines and distributary channels that are observable in airphotos taken over the last half century. These include subsidence, density currents, permafrost and vegetation, quantity and size of sediments carried to the Delta, and waves, currents, and ice on Great Slave Lake. Hydrologic and sediment factors are discussed in greater detail in Section 6 of this report.

5.1 Compaction Subsidence

There are two major phases in the cycle of a delta. In the constructional phase the river extends lakeward (or seaward); in the destructional (erosional) phase the lake or sea encroaches upon newly formed delta land. Both phases have distinct identifying characteristics, and both are evident along the shore of Great Slave Lake between Fort Resolution on the west and the mouth of the Talston River on the east (Figure 17). Shoreline erosion east of the Resdelta Channel is believed to be caused in part by compaction subsidence, since the deposits in the Slave Delta are loose and fine grained (see also Figure 11).

Following abandonment of the delta distributary system east of Resdelta Channel, active sedimentation appears to have essentially ceased while subsidence continued. The effects are most pronounced in the large interdistributary basins that form lagoons or contain marshes and ponds between Resdelta Channel and the Talston River. Because levees are heavier than adjacent marshes, they subside more rapidly; and with continuing subsidence and wave and current erosion, the marshes and swamps tend to enlarge and coalesce (Figure 18). In a few years some of the marshy interdistributary basins may become open bays or small lakes. This change from marsh land to open water in shoreline bays appears to have been accompanied by diversion of the Slave River to the west, where the active delta is located.

The process of subsidence from compaction should be distinguished from tectonic downwarping or isostatic rebound following deglaciation. Figure 19 suggests that glacier ice retreated from the Slave River Lowland about 10,000 years ago. The role played by isostatic rebound in Slave Delta modification is unclear. However, it is no doubt partly responsible for the low gradient of the Slave River.

5.2 Density Currents

At river mouths the density difference between inflowing river water and adjoining basin water is caused by differences in suspended sediment and temperature, and by salinity in the case of deltas built into the sea. If the density difference is large, the spread of the inflowing stream is restricted and this in turn influences the rate of sediment deposition and the morphology of the delta front. Contrasts in the density of inflowing river water and that in the receiving basin may give rise to density currents, which can be very significant. The occurrence of density currents off the Slave Delta is suggested by the appearance of the sediment plume so clearly outlined in Landsat imagery, and shown on the five 35-mm slides forwarded to Gordon Lewis on January 30, 1980.

On the basis of the position of the density currents relative to the boundaries of the surrounding fluid, overflow (surface), interflow, and underflow (bottom) currents can be distinguished. Density currents that have a higher content of suspended sediment than the enclosing fluid are called turbidity currents; and they are the most important. Turbidity currents may also be produced by waves, which stir up bottom sediments, and by subaqueous slides forming along delta-front slopes. It is not possible to determine how significant these are without field measurements. Density currents affect the prodelta morphology by forming gullies, reducing the slope on foreset deposits, and forming gently sloping bottomset beds that extend far out into Great Slave Lake.

In interpreting the Landsat imagery, an attempt was made to distinguish three types of inflow situation: (a) where the inflow is denser than the ambient fluid and forms a turbidity current, which inhibits mixing; (b) where the inflow water is similar in density to the receiving water and, given sufficient depth offshore, mixes readily in three dimensions, producing topset, foreset, and bottomset beds; and (c) where the inflow water is less dense and spreads over the surface as a bouyant plane jet. Unfortunately, these three types of inflow could not be confidently distinguished in the absence of field data.

The two colour composite Landsat images, and the two digitally processed images submitted earlier all show the extent of offshore sediment, apparent changes in sediment concentration, and what appear locally to be the effects of density currents. In August 1975, for example, the area of suspended fine sediment off the Slave Delta extended 35 km out into Great Slave Lake and covered an area of approximately 6000 km^2. In July 1980 the area of suspended sediment was much less -- approximately 2500 km^2.

5.3 Climate and Vegetation

At the Slave Delta the main contributions of climate are the creation of waves and currents from winds, the formation of lake and river ice (agents of destruction), the development of shoreline-stabilizing subarctic vegetation, and the creation of permafrost conditions. All factors are significant at the Slave River Delta.

Vegetation and permafrost conditions change from area to area over and upstream of the active and inactive delta (Figure 18). Both are associated closely with surface drainage conditions. The drier sites tend to be more heavily wooded. Moreover, insulation, shade, and the accumulation of snow in the branches of conifers (mainly spruce) promote permafrost development or its retention once formed. Where it is dry, sphagnum peat promotes the preservation of permafrost in bogs. In the Slave Delta, all wet fens, marshes, and swamps with standing water are believed to contain no permafrost. Characteristic vegetation, and existence and depth to permafrost, can also be correlated closely with landforms and surface materials (see Figure 18).

The effect of microclimate differences on winds, waves, currents and drift ice can be substantial along the shores of the Slave Delta. For example, wave and ice action is expected to be less in Nagle Bay, which is protected to some extent by islands and a spit. As a result, clusters of emergent plants (e.g. scirpus acutus) can be seen in the 1966 normal colour airphotos (Figure 38). Nevertheless, some sets of airphotos show strong suspended sediment movement patterns within Nagle Bay, possibly formed by incoming waves or longshore currents.

Airphotos and maps of the Slave River Lowland show a lack of wind-blown sand dunes along present and former sand deltas, such as occur on the delta plains where the Liard River and Great Bear River join the Mackenzie River. The reason for the lack of dunes behind the present shoreline and on raised sandy beaches in the Slave River Lowland may be rapidly colonizing vegetation. It may also be the presence of substantial amounts of silt and clay in very fine sand (versus dominantly clean fine sand in the 0.1 to 0.5 mm range).

Vegetation seems to play an important role along the Slave Delta shoreline by stabilizing the soils above the reach of wave action. Organic materials form resistant masses against currents and waves, and the roots of woody scrub brush also stabilize the soil against erosion. Such stabilizing vegetation is assisted by the paucity of 0.1 to 0.5 mm sand particles reaching the coast, as noted above at Nagle Bay, and by offshore islands, spits, submerged bars and shoals that blunt the attack of waves and currents.

Thermokarst development appears to be uncommon in the active delta, as revealed by the nine sets of airphotos extending over a period of a half century, but is extremely common on land above the modern Slave Delta (Figure 18).

CHAPTER 6

HYDROLOGY AND SEDIMENTATION

K. F. Davies, in his report on the Slave River Delta hydrology dated February 1981, notes that wildlife within the Delta depends on annual floods carrying nutrient-rich sediments.

Davies also states that ". . . approximately 86% of the flow in the summer months passes through the Resdelta Channel, 5% through the Middle Channel West, and 9% through the remaining 5 channels. During winter periods these percentages change to 93%, 5% and 2% respectively. Flows close to zero were observed in some of the smaller channels during the winter months. Water levels fluctuate up to three metres from low fall conditions to high spring peaks during breakup periods. Two distinctly different spring breakups were observed during the study period. The 1979 breakup was a late breakup with high water levels and subsequent flooding of most of the delta complex. The 1980 breakup was relatively warm and early with low flows and minimal flooding of the delta lowlands.

"Water level fluctuations of 2 to 3 metres, the result of ice jams in the spring freshet, are the predominant cause of flooding of the wetlands within the delta. Water levels from high flood peaks in June, July, and from wind action on Great Slave Lake affect these areas to a lesser extent."

Davies further notes that his study encompassed only two spring breakups and a limited range of flows, and that a much larger range of flows and spring breakups should be monitored.

6.1 Comparison of the Slave, Athabasca, and Mackenzie Deltas

The Athabasca, Slave, and Mackenzie Deltas are three major deltas of the Mackenzie River basin. The Athabasca and Slave Deltas together receive virtually all the sediment load of the Athabasca and Peace River systems, whereas the Mackenzie Delta receives only sediment that originates from the Liard and Mackenzie River systems downstream of Great Slave Lake.

Table 6 gives a comparison of a few statistics for the three deltas. The most notable feature is the small surface area of the Slave Delta in relation to water and sediment inflows, which results from the large depth of water into which it is advancing offshore.

The approximate area quoted for the Slave Delta (Figure 6) includes the active and inactive parts of the modern delta. The active delta area is about 20% of the total area of the modern delta.

6.2 Great Slave Lake: Depths, Levels, Waves, and Ice

Figure 6 is based on Canadian Hydrographic Service Hydrographic Chart 6370, and shows depths of water in feet. Depths reach 30 m only 2 km offshore. The shallow area south of Old Steamboat Channel may reflect past long-continued sedimentation. The main river flow into Great Slave Lake now discharges to the north via Resdelta Channel.

Daily water level data are available for 1934 and for the period 1938-79. Statistics are summarized in Table 7. The period 1968-71 is anomalous due to filling of Williston Reservoir (Bennett Dam) on the Peace River, as shown by Table 8. Monthly levels for the period 1971-79 are plotted in Figure 20.

Wave data are apparently available only for a point in about 20 m water depth off Hay River, where a recording buoy was situated from 18 June to 30 September 1975. Statistics in Table 9 are based on a data report from Environment Canada (1975). Conditions at this location are probably similar to those off the Slave Delta.

Information on lake ice conditions near Hay River was obtained from a paper by Noble and Comfort(1980). Maximum ice thickness is typically 1.2 m in late April. Pressure and shear ridges tend to form 2 to 3 km offshore. Typical ridge dimensions are a spacing width of 30 m, a sail height of 1 to 2 m, and a keel depth of 4 to 8 m. According to the Hydrological Atlas of Canada (1978), freeze-up normally occurs about 1 November and the lake is ice-free about 15 June.

6.3 Slave River Inflows

Figure 21 shows a mean water balance for Great Slave Lake. The Slave River contributes about 85% of the annual outflow from Great Slave Lake. Figure 22 shows a hydrograph of Slave River flows at Fitzgerald, virtually the same as at the head of the Delta. The effect of Bennett Dam on the Peace River can be seen in reduced flow volumes during the filling period 1968-71, and in increased winter flows and reduced summer flows since 1972. Figure 23 shows the mean flow distribution by months for the present regime.

Table 10 lists some flow statistics of the Slave River. The highest flow recorded was in May 1974 during the ice break-up period. Before the completion of Bennett Dam, no annual maxima were recorded before June 11; therefore, it seems possible that the 1974 event was caused by more severe ice conditions and jamming resulting from Peace River regulation.

6.4 Distributary Flows and Delta Water Levels

Limited distributary discharge data for 1978-79 are contained in a preliminary report by Environment Canada (1980) for gauging sites shown in Figure 24. Approximate ranges in flow indicated by these data are listed in Table 11. The most easterly Resdelta Channel carries about 86% of the total flow; the Middle and West Channels carry about 6%, and the rest carry 8%. It appears likely that there has been a dramatic shift in distribution within the historical period, as shown from aerial photographic evidence.

In the 1978-79 observation period, the highest water levels were caused by ice jams in May 1979. These jams resulted in flooding of a large part of the delta. The highest summer levels in 1979 were about 1 m lower. The total range in levels at several of the gauging sites was about 2 m.

6.5 Sediment Inflows

Suspended sediment in the Slave River has been measured at Fitzgerald since 1972, after completion of Bennett Dam. It is likely that the effect of the dam has been fairly small. Nevertheless, some reduction may have occurred in sediment inflows, mainly due to reduction in summer flows. The post-1972 mean annual sediment load is about 30×10^6 tonnes, or in volumetric terms around 20×10^6 m^3 of deposited sediments. Over 50% of the inflow occurs in June/July, with the rest mainly in May, August, September, and October (Table 12).

Bed load in the Slave River is likely to be very small in relation to suspended sediment load.

Typical size distributions in Slave River suspended sediment are 10% sand, 65% silt, and 25% clay.

Typical sediment concentrations in June/July are in the range of 100 to 500 mg/ℓ, with periods of a few days up to several thousand mg/ℓ. A daily maximum of 7600 mg/ℓ was recorded in 1972; the corresponding daily sediment load was 5×10^6 tonnes, 1/6 of the average annual load. Typical daily loads in June/July are in the order of 200,000 tonnes.

The average annual sediment concentration appears to be about 250 mg/ℓ. In terms of western Canadian rivers this is a moderate figure. The relatively high sediment loads of the Peace and Athabasca basins are somewhat diluted by runoff from Canadian Shield drainage into Lake Athabasca. Also, part of the Athabasca sediment is retained in the Athabasca Delta.

If a hydroelectric dam is built at Mountain Rapids on the Alberta-Northwest Territories boundary, all of the sand and most of the silt will be deposited in the reservoir, which will take many centuries to fill with sediment. This could have implications for the stability of the Slave Delta.

6.6 Sediment Balance Versus Delta Changes

On the basis of certain assumptions, a theoretical rate of delta advance can be calculated from known sediment inflow. The following assumptions are made:

1) the average sediment inflow is 20×10^6 m^3/yr;
2) 50% of the sediment inflow is deposited in the delta, and the rest is dispersed in Great Slave Lake;
3) the water depth at the delta front is 30 m.

The corresponding rate of areal advance can thus be estimated as:

$$\frac{0.5 \times 20 \times 10^6}{30} = 0.33 \times 10^6 \text{ m}^2/\text{yr}$$
$$= 0.33 \text{ km}^2/\text{yr}$$

The total advance in the period 1930 - 1973, as indicated by the aerial photographs, is about 1.5 km over a 20-km long front. The average areal rate is accordingly:

$$\frac{1.5 \times 20}{43} = 0.7 \text{ km}^2/\text{yr}$$

This comparison seems to indicate that the proportion of sediment dispersed in Great Slave Lake may be quite small.

6.7 Regime Characteristics of the Lower Slave River

Table 13 lists some prominent features of the Lower Peace and Slave Rivers. The river distance from the start of the Slave River, at the junction of the Peace River and Rivière des Rochers, to the head of the Delta is about 430 km. The river distance from the lower end of the rapids at Fort Smith to the head of the Delta is nearly 300 km*.

Figure 25 shows a slope profile. The slope of the Lower Slave River is very flat -- only 0.033 m per km. Figure 26 shows locations and median grain sizes (D_{50}) for a series of bed and bank material samples along the river. The bed material is mainly sand, with a median size of about 0.2 mm. Cross-sectional dimensions of the channel average about 700 m wide and 7 m deep at high water (July).

Regime analysis indicates that the channel slope is more or less a bare minimum for maintenance of a mobile bed. Bed load transport can be expected to be very small except at high flow conditions.

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*See Figure 17 at scale 1:200,000. In a direct line from Fort Smith to Great Slave Lake the distance is about 165 km.

Geological information on crustal rebound (Quigley, 1980; Clark and Persoage, 1970) indicates that the Slave Delta area is presently rising in relation to Fort Smith, with a differential rise in recent millennia in the order of 2 mm/yr. The question arises as to whether this might cause an appreciable loss of sediment to storage between Fort Smith and the Slave Delta. For a river length of 300 km and a width of say 1 km, the annual volume of sand accumulation in a wedge would be approximately:

$$0.5 \times 300{,}000 \times 1000 \times \frac{2}{1000} = 300{,}000 \text{ m}^3/\text{yr}$$

Since the sand fraction of the river's suspended load is about 2,000,000 m^3/yr, it appears that crustal rebound could not account for storage of a substantial proportion of transported material.

6.8 Delta Morphology Changes as Shown by Nine Sets of Aerial Photographs, 1930 - 79

Table 14 summarizes hydrologic conditions, where known, for nine sets of aerial photographs from 1930 to 1979. In assessing apparent differences between the aerial pictures of different dates, water levels in Great Slave Lake are of considerable importance because of the very low relief of the Slave Delta. Table 13 shows that the total range in water levels shown in the entire sets of aerial photographs is about 0.6 m, which could make a big difference to apparent shoreline locations. Unfortunately, recorded water levels are not available for 1930, but on the basis of a longer record for Lesser Slave Lake it is considered likely that the level was about average for the time of year. Estimates of wind set-up for a lake 50 m deep, a fetch of 160 km (from the W and NW), and a wind velocity of 112 km/hr in the direction of the fetch, indicate a possible maximum above still lake level of about 1 m (Saville et al, 1962, p. 103).

Comparison of sets of photographs from 1930, 1946, 1960, 1966, 1970, 1973, 1979 show the following information (see Figures 26 to 37):

1930 - 1946 (Figs. 26,30,34)	The active delta apparently extended into the lake by an average distance of about 0.5 km in the Nagle Bay area (Figure 26) and 1 to 2.5 km in the East Channel/Resdelta Channel area (Figure 30).
1946 - 1960 (Figs. 27,31,35)	Much less change is evident, with local advance generally less than 0.5 km at Nagle Bay (Figure 27). The shoreline appears to have retreated, however, between the East Channel and Resdelta Channel (Figure 31).
1966 - 1970 (Figs. 28,32)	Main advance (0.5 to 1 km) appears to be concentrated around the mouth of Old Steamboat Channel (Figure 28) and west of the mouth of Resdelta Channel (Figure 32).
1960 - 1973 (Figure 36)	A slight shoreline advance is detectable at the west end of the Delta. Also, further reduction of the central channels is apparent.
1930 - 1979 (Figs. 29, 33)	Major advances in the shoreline (0.5 to 2 km) are apparent when the airphotos from 1930 and 1979 are compared.

Although there are differences in lake water level between these sets of aerial photographs, it seems questionable whether these can explain the apparent advance of the delta shoreline by 1 to 2 km between 1930 and 1946 and the much smaller change since then.

It may be that the advance between 1930 and 1946 represents an episode in a jerky process of advance. As noted by Axelsson (1967), in the presence of waves and longshore currents, deltas may exhibit alternating constructional and destructional phases. This behaviour is clearly suggested by the indications of delta building and shoreline retrogression evident in Figure 17. The original of this figure, at a scale of 1:63,360, revealed scarplets and the downstream ends of distributaries truncated by beach ridges.

It appears that in the last several millennia there have been five major episodes of active delta building that have been terminated eventually by wave and longshore current erosion with the formation of beach ridges. Beach ridges and/or eroded shores (spits) occur on the opposite side of the main channel of the Slave River from active delta building, and the two activities take place at the same time.

Figure 37 shows the location of an outer submerged bar that appears to mark a change in slope at the delta front. Figure 37 is a print of a mosaic made from airphotos taken in July 1960.

CHAPTER 7

CHANGES IN AQUATIC AND TERRESTRIAL VEGETATION FROM 1930 TO 1979

The effect of changing Slave Delta conditions on waterfowl and wildlife is significant to native people dependent on them for food or fur.

Changes in shoreline hydrography over time are depicted in Figures 26 to 37; these figures also show similar changes in nearshore vegetation. Inspection of Figures 26 to 33 reveals changes in vegetation between different years, with the changes outlined.

Figure 38 shows that emergent vegetation in shoal nearshore waters frequently grows in circular rings. This aquatic vegetation is likely Hardstem Bulrush (*scirpus acutus*), whose rhizome roots grow radially outward and deplete the fine-grained lake bottom sediments of nutrients, much as fairy rings caused by a fungus (*mycellium*) do in a residential lawn. Although the ring structure in the emergent vegetation is thought to result from radial impoverishment of plant nutrients, it is also possible that the roots may secrete toxic substances.

The emergent vegetation seen in Figures 26 to 38 could also be *scirpus validus*, but the chances of this seem less likely. If the emergent vegetation is largely *scirpus acutus*, the plant is 2 to 3 m high and usually grows in water depths of 1 to 2 m.

Hardstem Bulrush is a favored nesting site for several species of ducks, including cinnamon teal, gadwall, lesser scaup, and redhead — with the latter two species more likely to be found in the Slave Delta area.

Examination of the several sets of airphotos reveals that scirpus acutus (and perhaps other species of scirpus plus duckweed, pondweed, etc.) usually grows in shoal waters of the nearshore zone -- commonly in places where the vegetation is protected from severe wave attack in the open water season and from disturbances by drift ice during spring break-up of lake ice -- in other words, in shallow bays and in lagoons behind spits and barrier islands (see Figures 26 to 33 and Figures 37 and 38).

The vegetation on both sides of Old Steamboat Channel and Nagle Channel may be used as an indication of change in terrestrial vegetation over a period of several decades. The colour photographs taken in the fall of 1966 show the typical vegetation situation bordering distributaries (see Figure 39). The yellow fall colours of balsam poplar readily distinguish it from the dark green colours of white spruce. Some of the willows and alders in the brush areas adjoining distributaries have also changed to fall colours. In Figure 39 the balsam poplar occurs in almost pure stands in small patches. A typical sequence landward from distributary shorelines is horsetail (Equisetum), willow, alder, balsam poplar on higher but moist soils, with white spruce on still higher ground above balsam poplar.

Because the highest areas are no more than 3 m above river level the area is subject to frequent flooding. Because black spruce is intolerant to flooding for periods of 30 to 40 days, there is likely very little black spruce growing on the active part of the Slave River Delta. However, this could change significantly if construction of an upstream reservoir sharply reduced flooding within the Delta. Black spruce might eventually flourish, encroach on distributary shores and "push out" the horsetail, willows, alders and balsam poplar that presently support different species of wildlife and waterfowl.

CHAPTER 8

STUDY FINDINGS

The interpretation of nine sets of contact airphotos, several Landsat images, and several maps and reports, has resulted in a number of findings, which are itemized below:

1 In August 1975 the Slave River discharged a plume of suspended fine sediment that spread 35 km out into Great Slave Lake. This sediment was re-distributed by waves and currents over a lake area covering some 6000 km^2. In July 1980, however, the suspended sediment dispersed over 2500 km^2 of lake surface, based on evidence in Landsat images.

2 The active subaqueous delta platform extends lakeward to the delta front from the present-day shoreline. The delta front generally lies between 1 and 2 km beyond the present shoreline from Nagle Bay to a point west of Resdelta Channel. However, the delta front extends about 4 km out into Great Slave Lake opposite Resdelta Channel, recently the main distributary channel. Beyond the delta front the lake bottom would seem to drop off rapidly to depths of 10 to 30 m or more.

3 The distributary channel width at two sections on Old Steamboat Channel was reduced from 250 m to 100 m and from 250 m to 150 m between August 21, 1930, and July 10, 1973. On the other hand, at two sections on the Resdelta Channel the width of the distributary increased from 175 m to 315 m and from 200 m to 450 m between August 21, 1930, and July 10, 1973. It is expected that bankfull discharges changed correspondingly in these main distributaries, more or less as the square of width changes. Distributaries into Nagle Bay and north to the midpoint

of the active delta have continued to shrink, while at the same time Resdelta Channel has enlarged significantly.

4 Shoreline advance in the active delta region appears to be rather jerky. Episodes of rapid advance are followed by nearly stable conditions for several years -- or even by local retrogression. The rate of delta advance is also seen to vary along the length of the active delta shoreline.

5 North of Fort Smith the Slave River follows a course roughly midway between the Talston River and the Little Buffalo River. Over postglacial time active delta building appears to have alternated from one side of the main position of the Slave River to the other, especially north of latitude 61°00'. While active delta building (progradation) takes place on one side of the Slave River Lowland, the opposite side appears to undergo beach ridge or spit building accompanied by some intermittent beach erosion.

6 Sediment carried by the Slave River is generally so fine that beach ridges contain mostly fine sand, with very little if any coarse sand or gravel sizes. Most raised beach deposits in western Canada are composed of clean well graded sands with minor gravel sizes. In addition, the raised beach ridges in the Slave River Lowland are either obscure or very weakly expressed in the present-day landscape at several locations inland from the coast of Great Slave Lake.

7 Nearshore vegetation flourishes in warm, shallow, nutrient-rich waters, in sites that are more or less protected from wave

and ice action. Emergent vegetation in the quiet waters of bays and lagoons forms and eventually disappears behind spits and behind barrier islands. Thus the location of nearshore vegetation changes with changes in the morphology of the active delta. The principal emergent vegetation is thought to be Hardstem Bulrush (scirpus acutus).

8 The gradient on the Slave River is thought to have flattened over postglacial time, owing to differential isostatic rebound following deglaciation, and to longtime delta front progradation over the last roughly 10,000 years. Taking an average shoreline advance of 1½ km over 50 years (Sawmill Channel to Resdelta Channel over the interval), the distance of shoreline advance over postglacial time (10,000 years) is 300 km. This 300 km figure corresponds to the river length from the lower end of Smith Rapids to the present shore of the delta at Great Slave Lake, which is about twice the direct distance between these same points.

9 The rate of delta advance could have been greater during the first several years after deglaciation because there is very little evidence of beach ridge building between latitude 60^{o} and latitude 61^{o}. After the delta front reached latitude 61^{o}, however, the process of delta advance seems to have been more erratic, with more frequent episodes of shoreline stability and/or local retrogression alternating with episodes of delta progradation on the opposite side of the Slave River Lowland.

10 Slave Lake is deep (up to 614 m at its deepest) and covers some 28,400 km^2, much of the sediment transported is fine (silt/clay), the steeply sloping delta front is situated quite close to

the present shoreline (note that it is even much closer in the inactive delta portion), and wave and current action are strong. All these factors cause fine sediment to be carried far out into the lake, where it settles very slowly to the lake bottom.

11 Fluctuating water levels in delta distributaries could become more regulated in the future with construction of a dam at or near Mountain Rapids. If distributary water levels become stabilized, with very little or no active delta flooding in the future, the result could have a significant effect on wildlife that depends on horsetail, willows, alders, and balsam poplar growing along or near the shores of distributaries. With the reduction in delta flooding, black spruce, which is very intolerant to flooding for extended periods, may eventually encroach upon the shore, "pushing out" the vegetation that is now used by waterfowl, muskrat and beaver. In other words, flooding of the delta in the spring and slow drainage of the flood waters out of sloughs in distributaries, marshes, and swamps for the rest of the year would seem to be a desirable consequence for the support of wildlife in the Delta area.

CHAPTER 9

SYNTHESIS

The geomorphology and vegetation of the Slave River Lowlands, including the Slave Delta at its northern edge, were studied in nine sets of airphotos taken over a period of 50 years. These airphotos reveal the geomorphology and postglacial development of the Delta over the last several millennia, and historic changes that have taken place over the past half century -- particularly changes in the Delta shoreline, and decreases and increase in the width of active distributary channels over time.

Five satellite images, four of them colour composites, reveal the areal extent of suspended sediment in Great Slave Lake, off the mouth of the Slave River. Away from the distributary channels, the active and inactive portions of the Slave Delta appear to have been relatively stable over the past half century. This stability might change, however, if the present frequent flooding of the Delta is reduced through construction of a dam and reservoir at or near Mountain Rapids -- something that should be looked into if it has not already been done.

The study reported here represents an attempt to bring together interpreted geomorphic data on the evolution of the Slave River Delta and available data on hydrology and sedimentation. At the same time, an examination was made of the vegetation,and changes in vegetation,in the Delta because both water and vegetation affect the vitality of wildlife in the Delta. Accordingly, the two main maps (Figures 17 and 18) produced for this study show not only landforms, depositional environments, and surface materials,but drainage, vegetation, and permafrost conditions as well. All these biophysical factors -- in addition to flooding, sediment load, and characteristics of Great Slave Lake -- have an important bearing on the productivity of the Slave Delta and its maintenance in the future.

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ACKNOWLEDGEMENTS

Tables 7, 8, 10, 12, and 13 and Figures 20, 21, 22, 23, 24 and 25 are extracted from or based on a report prepared by Northwest Hydraulic Consultants for the Slave River Hydro Feasibility Study, sponsored by Alberta Environment. This information is reproduced by permission of Alberta Environment (see attached letter).

The three oblique photographs at the end of this report were taken from the air by Northwest Hydraulic Consultants Ltd. in July 1980.

R. L. WALKER & PARTNERS LTD.

CONSULTING ENGINEERS AND ECONOMISTS

Suite 201
9924 - 106 Street
Edmonton, Alberta
T5K 1C4
Canada

Tel. (403) 429-7296/7

January 22, 1981

Northwest Hydraulic Consultants Ltd.
4823 - 99 Street
Edmonton, Alberta
T6E 4Y1

ATTN:E.K. Yaremko

re: Use of Slave River Hydro Feasibility
Study Data

Dear Sir;

With reference to your letter of January 21, 1981 regarding the use of information generated in the Slave River Hydro Feasibility Study for your studies of the Great Slave Lake delta, this is entirely in line with Alberta Environment policy. We would appreciate receiving a statement of the information you use however, for our records and would expect that relevant information generated through your study of the Great Slave Lake delta be made available to the Slave River study.

Yours truly,

R.L. Walker & Partners Ltd.

Dr. M.C. Swales
Resident Manager
MCS/jb
c.c. Carl Primus

Head Office: 65 Bank Street, Ottawa, Ontario, K1P 5K4. Tel. (613) 232-3745/6 Cables: ECENG

TABLE I.

Daily mean, maximum, and minimum temperatures, total precipitation, and rainfall at selected stations, 1931-60

		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
Temperature, F														
Daily mean	Fort Smith	-13.8	- 8.0	6.1	27.0	45.6	55.3	61.6	57.5	46.2	32.3	11.0	- 6.3	26.2
	Fort Resolution[1]	-14.9	-10.4	1.9	22.0	42.0	52.9	60.2	57.5	45.7	31.6	12.4	- 7.1	24.5
	Hay River	-12.2	- 7.8	3.8	23.6	40.8	51.6	59.8	57.7	46.8	33.1	11.2	- 6.2	25.2
Daily maximum	Fort Smith	- 4.5	2.8	18.3	38.8	57.4	67.9	73.8	69.9	56.0	40.1	18.4	2.3	36.7
	Fort Resolution	- 7.3	- 2.1	11.4	31.9	52.0	62.8	69.1	65.6	52.4	36.7	18.2	- 0.4	32.5
	Hay River	- 3.2	2.2	14.4	33.8	50.2	61.4	69.0	66.9	54.6	39.7	18.2	2.3	34.1
Daily minimum	Fort Smith	-23.0	-18.7	- 6.2	15.1	33.7	42.7	48.4	45.3	36.4	24.5	3.5	-14.9	15.6
	Fort Resolution	-22.4	-18.6	- 7.7	12.0	31.9	43.0	51.3	49.3	38.9	26.5	6.6	-13.8	16.4
	Hay River	-21.2	-17.8	- 6.9	13.3	31.3	41.6	50.6	48.3	39.0	26.4	4.1	-14.6	16.2
Precipitation, inches Total	Fort Smith	0.61	0.68	0.75	0.65	1.02	1.21	2.10	1.36	1.66	1.16	1.03	1.05	13.28
	Fort Resolution	0.46	0.52	0.37	0.47	0.78	0.97	1.33	1.36	1.64	1.34	1.52	0.79	11.55
	Hay River	0.63	0.60	0.58	0.64	0.93	0.98	1.66	1.47	1.55	1.38	1.32	0.90	12.59
Rain	Fort Smith	0.01	T[2]	0.1	0.17	0.91	1.21	2.10	1.36	1.53	0.44	0.04	0.01	7.76
	Fort Resolution	0.00	T	T	0.13	0.69	0.97	1.33	1.36	1.53	0.54	0.01	T	6.56
	Hay River	0.01	0.01	T	0.19	0.78	0.95	1.61	1.47	1.49	0.70	0.04	0.01	7.26

(modified from Doy, p13)

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[1] 22 years, 1931-60

[2] Trace

Variable	Delta plain Rate of growth is slow	 fast
Wave energy	high	low
Tidal regime	high	low
Offshore gradient	high	low
Rate of vegetation growth	low	high
Crustal subsidence	high	low
Sediment input	low	high

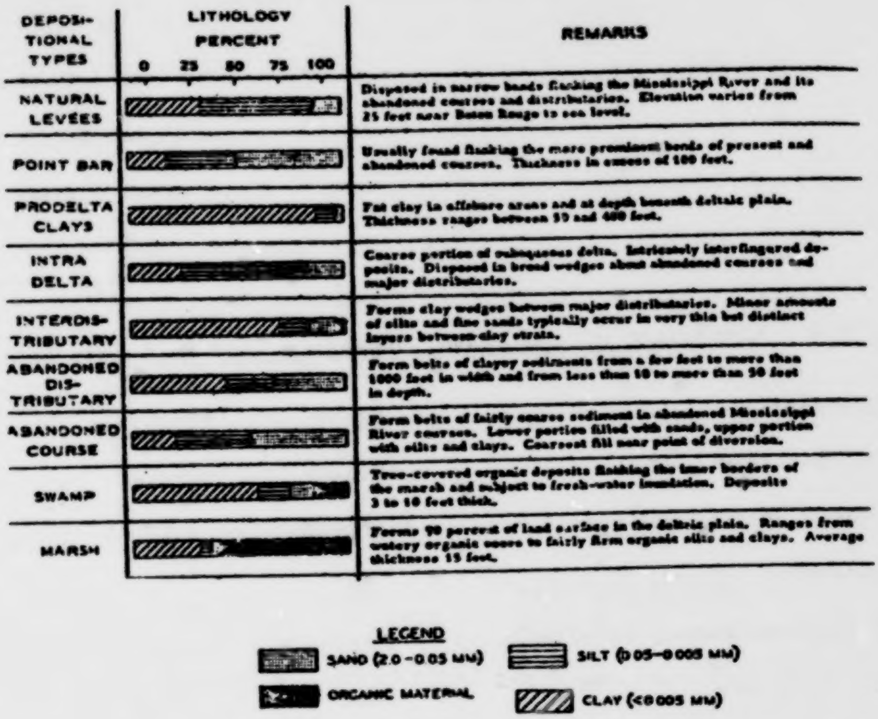
TABLE 2 Variables influencing the rate of delta front growth (from Ritchie and Brunsden, p. 68)

RIVER REGIME (Variations influence sediment load and transport capacity	Flood stage	Sediment load	Quantity of suspended load and bed load (that is, stream capacity) increases during flood
		Particle size	Particle size of suspended load and bed load (that is, stream competence) increases during flood
	Low river stage	Sediment load	Stream capacity diminishes during low river stage
		Particle size	Stream competence diminishes during low river stage
COASTAL PROCESSES	Wave Energy		High wave energy with resulting turbulence and currents erode, rework, and winnow deltaic sediments
	Tidal range		High tidal range distributes wave energy across an extended littoral zone and creates tidal currents
	Current strength		Strong littoral currents, generated by waves and tides, transport sediment alongshore, offshore, and inshore
STRUCTURAL BEHAVIOR (With respect to sea level datum)	Stable area		Rigid basement precludes delta subsidence and forces deltaic plain to build upward as it progrades
	Subsiding area		Subsidence through structural downwarping coupled with sediment compaction allows delta to construct overlapping sedimentary lobes as it progrades
	Elevating area		Uplift of land (or lowering of sea level) causes river distributaries to cut downward and rework their sedimentary deposits
CLIMATIC FACTORS	Wet area	Hot or warm	High temperature and humidity yield dense vegetative cover, which aids in trapping sediment transported by fluvial or tidal currents
		Cool or cold	Seasonal character of vegetative growth is less effective in sediment trapping; cool winter temperature allows seasonal accumulation of plant debris to form delta plain peats
	Dry area	Hot or warm	Sparse vegetative cover plays minor role in sediment trapping and allows significant aeolian processes in deltaic plain
		Cool or cold	Sparse vegetative cover plays minor role in sediment trappings; winter ice interrupts fluvial processes; seasonal thaws and aeolian processes influence sediment transportation and deposition

TABLE 3 Factors influencing deltaic sedimentation. These factors refer not only to large deltas built into the ocean, but also to large deltas built into large present-day lakes (from Morgan, p. 33).

Environment of deposition	*Deposit*	*Origin reflected in typical stratigraphical position*
Channel floor	Channel-lag deposit	Channel or substratum deposits
Point bar	Point bar deposit	
Channel bar	Channel bar deposit	
Point bar swale or in abandoned braided stream channel	Swale-fill deposit	
Levee	Levee deposit	Overbank or topstratum deposits
Crevasse-splay	Crevasse-splay deposit	
Floodbasin	Floodbasin deposit	
Within abandoned or decaying channel	Channel-fill deposit	Transitional deposit

TABLE 4 Classification of alluvial deposits in subenvironments along the lower reaches of a meandering river,and their origin as reflected in their typical stratigraphical position (from Allen, 1965, p. 128).



LITHOLOGY PERCENT
0
25
50
75
100
LEGEND
SAND (2.0–0.05 MM)
SILT (0.05–0.005 MM)
ORGANIC MATERIAL
CLAY (<0.005 MM)

DEPOSITIONAL TYPES	LITHOLOGY PERCENT 0 25 50 75 100	REMARKS
NATURAL LEVEES		Disposed in narrow bands flanking the Mississippi River and its abandoned courses and distributaries. Elevation varies from 25 feet near Baton Rouge to sea level.
POINT BAR		Usually found flanking the more prominent bends of present and abandoned courses. Thickness in excess of 100 feet.
PRODELTA CLAYS		Fat clay in offshore areas and at depth beneath deltaic plain. Thickness ranges between 55 and 400 feet.
INTRA DELTA		Coarse portion of subaqueous delta. Intricately interfingered deposits. Disposed in broad wedges about abandoned courses and major distributaries.
INTERDISTRIBUTARY		Forms clay wedges between major distributaries. Minor amounts of silts and fine sands typically occur in very thin but distinct layers between clay strata.
ABANDONED DISTRIBUTARY		Form belts of clayey sediments from a few feet to more than 1000 feet in width and from less than 10 to more than 50 feet in depth.
ABANDONED COURSE		Form belts of fairly coarse sediment in abandoned Mississippi River courses. Lower portion filled with sands, upper portion with silts and clays. Coarsest fill near point of diversion.
SWAMP		Tree-covered organic deposits flanking the inner borders of the marsh and subject to fresh-water inundation. Deposits 3 to 10 feet thick.
MARSH		Forms 90 percent of land surface in the deltaic plain. Ranges from watery organic oozes to fairly firm organic silts and clays. Average thickness 15 feet.

TABLE 5 Summary of depositional types within the deltaic plain (left) and typical associated properties (right). The above grain size distributions are probably quite similar to those in depositional features (subenvironmental sediments) on the modern Slave Delta. Note that point bars and distributary beds are coarsest and that the finest material is prodelta (lake-bottom) clays, with slightly coarser sediments in interdistributary clays, with slightly coarser sediments in interdistributary floodbasins (bays in addition to marshes and swamps), which contain considerable organic matter. Natural levees, crevasse splays are intermediate in composition between point bars and channel beds on the one hand and prodelta clays and interdistributary floodbasins and bays. Compare with textural characteristics of three microlandforms shown in Figure 16. (From Kolb and Van Lopik, p. 58).

Table 6 Comparison of the Slave, Athabasca, and Mackenzie Deltas

Characteristic	Slave	Athabasca	Mackenzie
Morphologic type	Arcuate	Birdfoot	Estuarine
Mean water inflow, km^3/yr	118	23	350
Mean sediment inflow, $10^6 t/yr$	30	8	150
Ratio sediment/water, $10^6 t/km^3$	0.25	0.35	0.43
Approx. area, km^2	640	1730	12800
Ratio area/sediment, $km^2/10^6 t$	21	216	85
% sand in sediment inflow	10	20	10
Approx. depth of water at delta front, m	30	3	10

TABLE 6

Table 7. Great Slave Lake Water Level Statistics (based on period 1938-79)

Mean annual maximum	156.9 m
Mean annual minimum	156.4 m
Mean annual range	0.5 m
Highest in period (in 1962)	157.3 m
Lowerst in period (in 1947)	156.3 m
Historic range	1.2 m

Table 8. Comparison of Great Slave Lake Levels Over Three Periods

	Mean Annual Max.		Mean Annual Min.		Difference
Period	No. of Data	Lake Elev. (m)	No. of Data	Lake Elev. (m)	(Mean annual range) (m)
1934-67	31	156.93	31	156.38	0.55
1968-71*	4	156.74	4	156.27	0.47
1972-79	8	156.92	7	156.44	0.48

---

*Period of filling Williston Reservoir on Peace River.

Table 9. Great Slave Lake Wave Statistics Off Hay River, 1975

Statistic	Height (m)	Period (secs)
Maximum	4	8
Exceeded 10% of time	1	5.5
Exceeded 50% of time	0.5	3.5

Table 10. Slave River Flow Statistics

Mean flow (1960-67 & 1972-79)	3700 m^3/s
Mean annual maximum (29 years)	7200 m^3/s
Mean annual minimum (24 years)	1200 m^3/s
Highest recorded (1974)	11200 m^3/s
Lowest recorded (1953)	530 m^3/s

Table 11. Ranges of Flow in Delta Distributaries

Channel	Station number in Figure 6	Approx. range of flows 1978-79 (m^3/s)
Jean River	2	20 - 130
Nagle Channel	3	2 - 35
Old Steamboat Channel	5	10 - 130
West Channel	4	1 - 130
Middle Channel West	6	70 - 350
Middle Channel East	7	1 - 100
East Channel	8	1 - 130
Resdelta Channel	9	1500 - 6500

TABLE 12

DISTRIBUTION OF SLAVE RIVER SUSPENDED SEDIMENT LOAD BY MONTHS

MONTH	PERCENTAGE OF ANNUAL LOAD
January	0.8
February	0.7
March	0.7
April	0.7
May	15
June	27
July	27
August	14
September	6.9
October	4.8
November	1.6
December	0.8

PROMINENT FEATURES OF THE PEACE AND SLAVE RIVERS

KILOMETER DISTANCE[1]	GEOGRAPHIC LOCATION	MAJOR TRIBUTARIES	CHANNEL SLOPE[2]	CHANNEL FEATURES	DRAINAGE FEATURES	DRAINAGE AREA (km^2)
0	Peace Point			River meanders through the alluvial deposits of the Peace Delta. Numerous alluvial islands and channel bars.	Minor drainage from the flat terrain of the Peace Delta. Plus two major outflow channels from Lake Athabasca.	393,000
84	Rocky Point	Chenal Des Quatre Fourches	$5.0x10^{-5}$			
100	Start of Slave River	Riviere Des Rochers	———	River dominated by the western margin of the Canadian Shield that restricts the movement of the river. Numerous rocky islands and banks (some banks of sedimentary origin on the west side), minor rapids, active channel bars.	Minor drainage from the Canadian Shield to the east and from the Great Slave Plain to the west.	
156		Murdock Cr.				
158		La Butte Cr.	$4.3x10^{-5}$			
169	Hay Camp	Bocquene R.				
213	Fitzgerald		———	River drops over four sets of major rapids. The last presence of the Canadian Shield.		606,000
215		Dog River	$1.3x10^{-3}$			
240	Fort Smith		———			
250	Bell Rock/Cunningham Landing			The last outcrops of rock (sedimentary) occur at Bell Rock/Cunningham Landing. Downstream the river meanders through alluvial deposits. There is probably a geomorphic explanation for the extremeness of the Grand Detour meander. Channel bars and islands as continually eroding and forming. Moderate bank erosion in places. The Slave Delta has little relief. The most northerly channel (Resdelta Ch.) conveys most of the flow.	Apart from the Salt River which drains part of the Salt Flats of the Great Slave Plain, there is minimal surficial drainage in this reach.	
263		Salt River				
293	Start of Grand Detour					
383	Outlet of Rock Lake (Landry Creek)		$3.3x10^{-5}$			
497	Outlet of Ring Lake					
513	Jean River Divergence					
525	Nagle Channel Divergence					
528	Head of Slave Delta					
538	Great Slave Lake					609,000

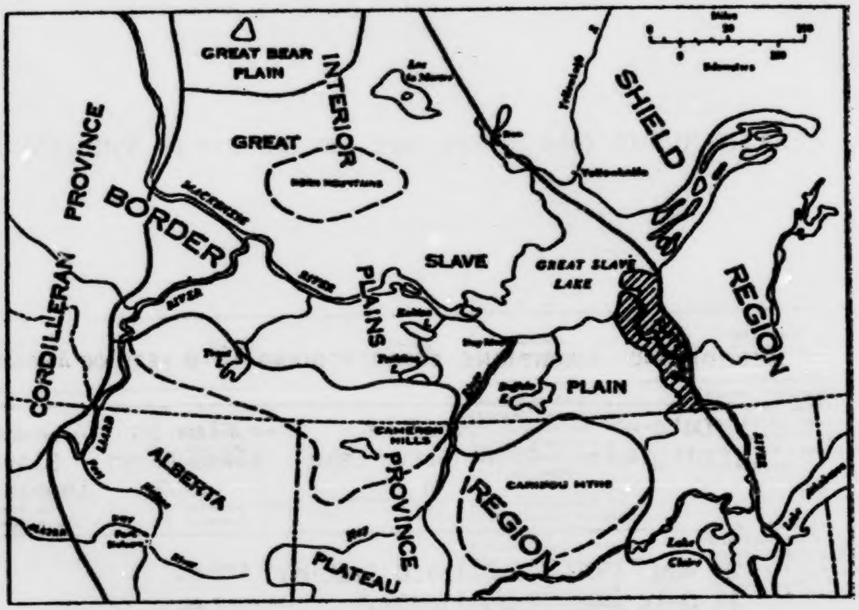
[1] Distances are river kilometers downstream of Peace Point on the Peace River, see Figure

[2] Slope refers approximately to average flow conditions.

TABLE 14

HYDROLOGIC CONDITIONS CORRESPONDING TO 9 SETS OF AERIAL PHOTOGRAPHS

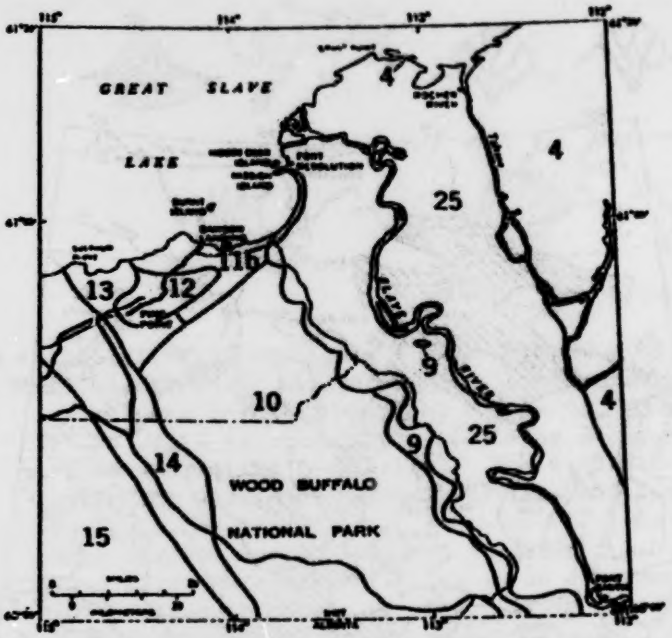
Date of photography	Level of Great Slave Lake m	Flow in Slave River m^3/s	Sediment in Slave River tonnes/day
21 Aug. 1930	157.0 (est'd)	--	--
11 July 1946	156.57	--	--
4 Aug. 1954	157.02	5360	--
27 Sept. 1957	157.05	4320	--
21 July 1960	157.06	6910	--
Sept. 1970	156.46	2920	--
16 Sept 1966	--	--	--
10 July 1973	156.79	5660	158,000
16 July 1979	156.98	5990	--


GREAT BEAR PLAIN
INTERIOR
GREAT
SLAVE
PLAINS
PROVINCE
CORDILLERAN
BORDER
MACKENZIE
RIVER
SHIELD
REGION
GREAT SLAVE LAKE
PLAIN
CAMERON HILLS
ALBERTA
PROVINCE
REGION
CARIBOU MTNS
PLATEAU
Yellowknife
Lake Claire

Physiographic divisions of the southwestern part of the Northwest Territories. (from Day, p 10)

▨ Slave River Lowland

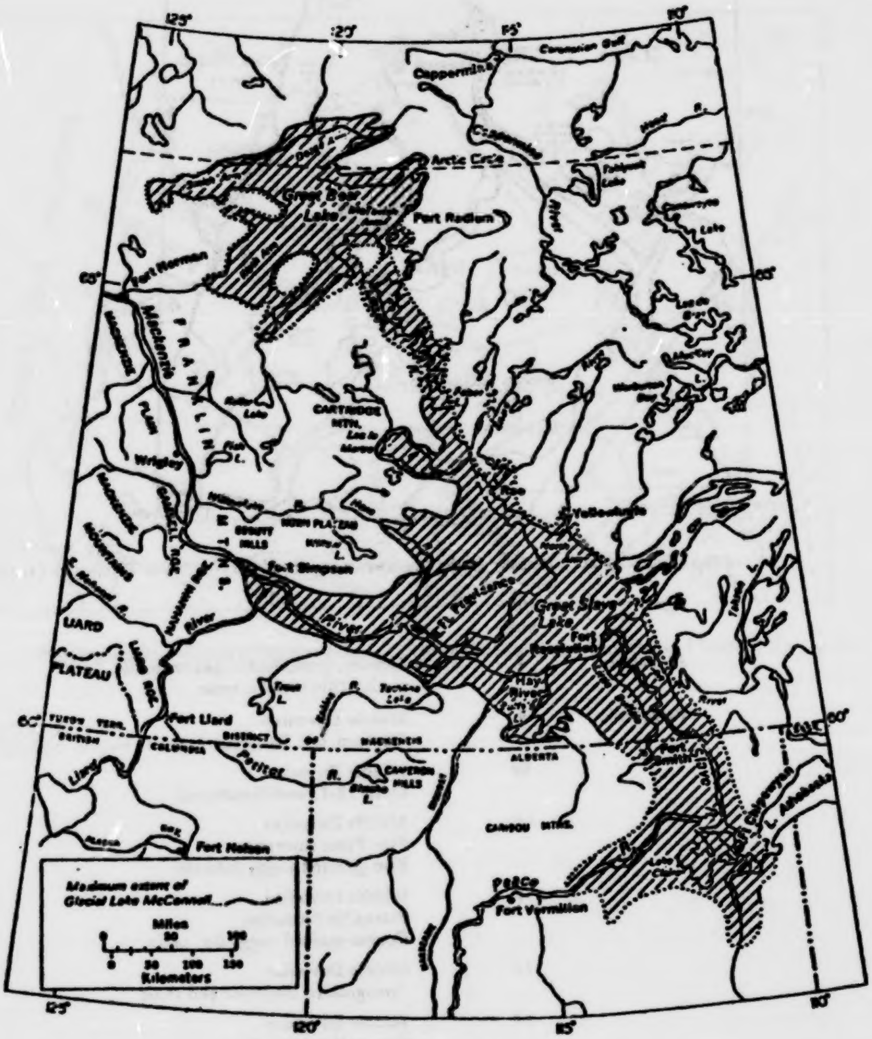
FIGURE I


115°
114°
113°
112°
GREAT SLAVE
LAKE
4
4
25
11b
13
12
SLAVE
RIVER
9
10
4
9
25
14
WOOD BUFFALO
NATIONAL PARK
15

Map of geological formations in the southwestern part of the Northwest Territories (from Day, p 15)

Age	*Map unit*	
Archaean	*4*	Granite, granodiorite, quartz diorite, gneiss, chloritized granite
Palaeozoic	*9*	Middle Devonian Gypsum, salt, limestone, breccia
	10	Middle Devonian Units 11-13 undifferentiated
	11b	Middle Devonian Pine Point formation Fine-grained vuggy dolomite
	12	Middle Devonian Presqu'ile formation Coarse-grained vuggy dolomite
	13	Middle Devonian Fine-grained limestone and shale
	14	Middle Devonian Fine-grained limestone
	15	Upper Devonian Shale, limestone, sandstone
Cenozoic	*25*	Pleistocene and recent deposits

FIGURE 2


125°
120°
115°
110°
65°
60°
Coronation Gulf
Coppermine
Coppermine
Hood R.
Arctic Circle
Great Bear
Lake
Port Radium
Fort Norman
Mackenzie
FRANKLIN
PLAIN
Wrigley
CARTRIDGE MTN.
Lac la Martre
Willowlake R.
NORTH PLATEAU
Fort Simpson
Fort Providence
Yellowknife
Great Slave
Lake
Fort Resolution
Hay River
LIARD
PLATEAU
River
Fort Liard
Tathlina Lake
YUKON TERR.
BRITISH
COLUMBIA
DISTRICT OF MACKENZIE
Petitot R.
CAMERON HILLS
ALBERTA
CARIBOU MTNS.
Fort Smith
Peace
Fort Vermilion
Fort Nelson
L. Athabasca
River
Maximum extent of Glacial Lake McConnell
Miles
0
50
100
0
50
100
150
Kilometers

Glacial Lake McConnell, ▨. (from Day, p17)

KEY MAP SHOWING GLACIAL LAKE McCONNELL

FIGURE 3

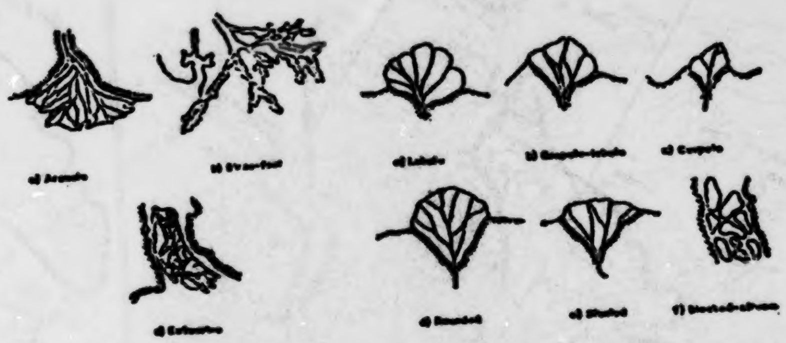
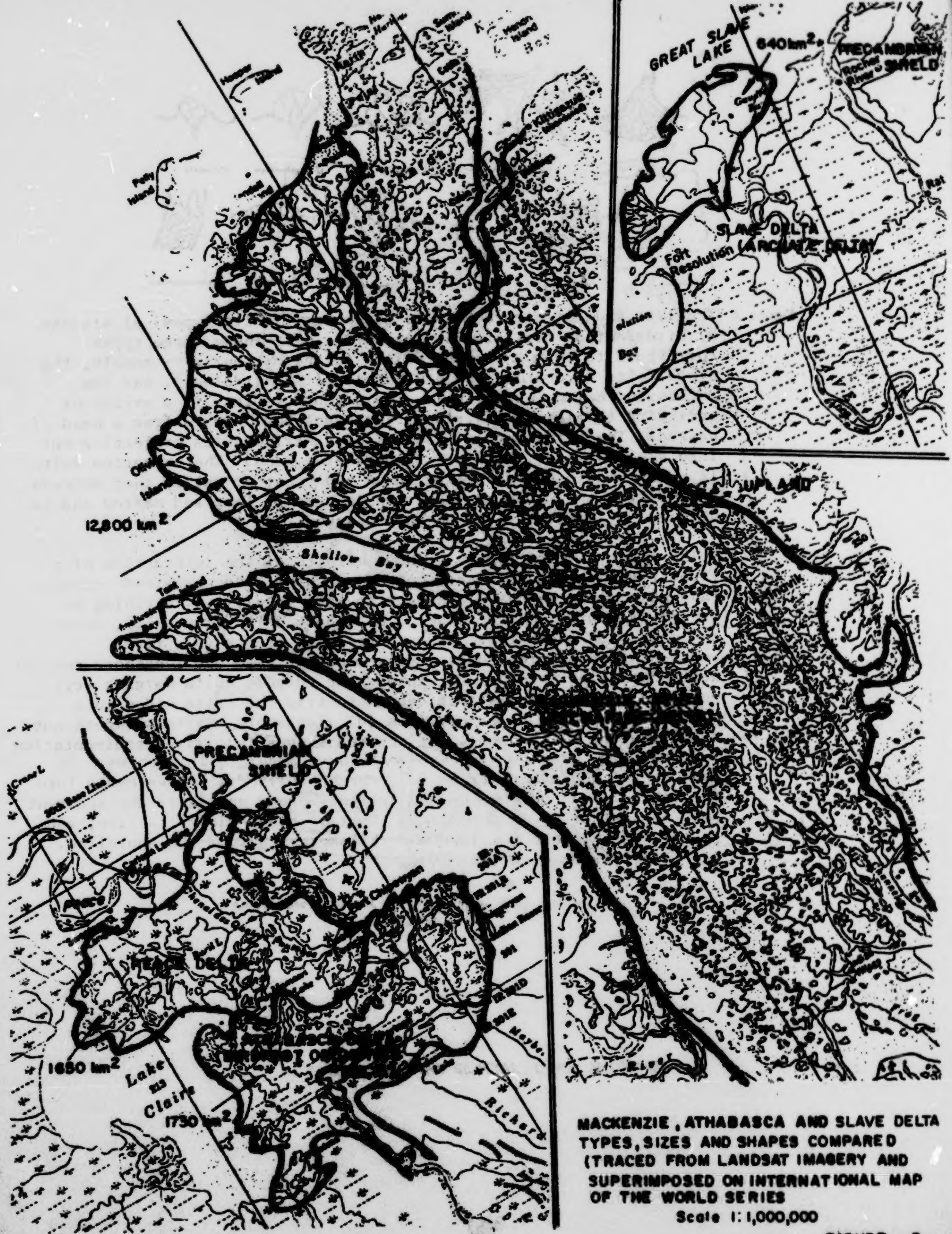


Figure 4 The left side of Figure 5 shows three basic delta types: a) arcuate, b) birdsfoot or digitate, and c) estuarine. These three types correspond to the three major deltas in the Mackenzie -- namely, the Slave delta (arcuate), the Athabasca delta (birdsfoot), and the Mackenzie delta (estuarine). The arcuate variety is a series of splitting (braiding) distributaries branching outward from a head of passes. The birdsfoot is a series of distributaries projecting out into shallow water, like the fingers of a hand. The estuarine delta is a soft sedimentary filling in an embayment or valley that extends inland from the ocean or lake. It is usually long and narrow and is bordered by higher ground on both flanks.

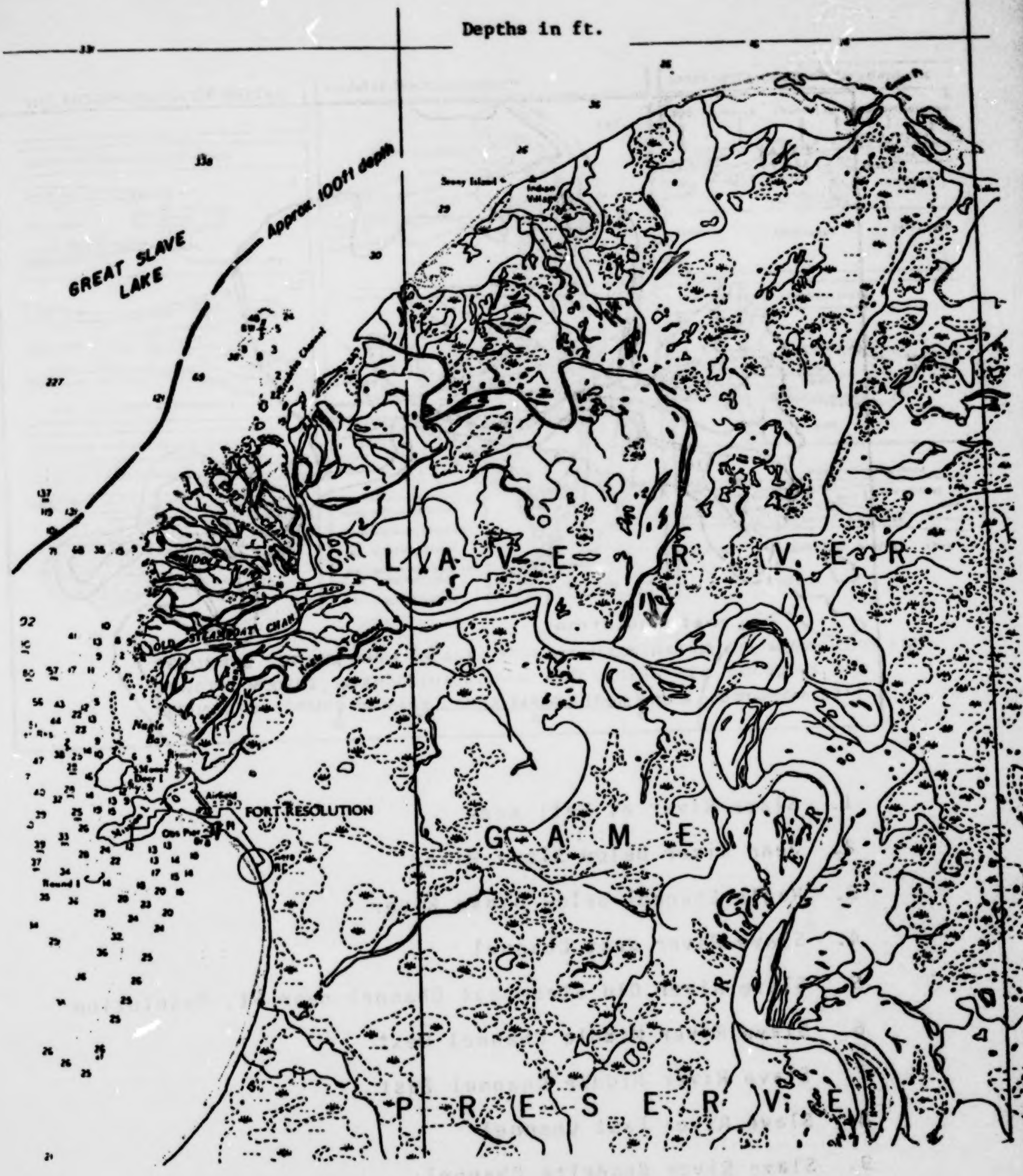
The right side of Figure 5 shows effects of the interaction of a river transporting sediment, on the one hand, and waves and currents (and also, in some cases, changes in lake level, i.e. a rising or subsiding shore), on the other. At lobate delta fronts (a), river sedimentation dominates. At cuspate delta fronts (b), river sedimentation or progradation dominates but wave and longshore current action modifies (erodes) the lobes. At cuspate delta margins (c), wave and currents are strong enough to trim the delta sides to a point. At rounded delta outlines (d), longshore currents smooth out the advancing delta front. At stunted shapes (e), river sedimentation and shoreline erosion processes both have moderate influences. In the case of a blocked stream (d), the shoreline is not extended into the lake or sea; here waves and currents erode and carry the sediment away as fast as it is deposited. Most of the sediment is fine, and is carried out into the lake many kilometers beyond the shoreline. (After Silvester et al, p. 203).


GREAT SLAVE LAKE
640 km²
PRECAMBRIAN SHIELD
Rocher River
SLAVE DELTA (ARCUATE DELTA)
Fort Resolution
Resolution Bay
Rat
Pelly Island
Olivier Islands
12,800 km²
Shallow Bay
UPLAND
PRECAMBRIAN SHIELD
Cree L.
28th Base Line
Peace
Fort Chipewyan
PEACE DELTA
1680 km²
Lake Claire
1730 km²
Richardson
River

MACKENZIE, ATHABASCA AND SLAVE DELTA TYPES, SIZES AND SHAPES COMPARED (TRACED FROM LANDSAT IMAGERY AND SUPERIMPOSED ON INTERNATIONAL MAP OF THE WORLD SERIES

Scale 1: 1,000,000

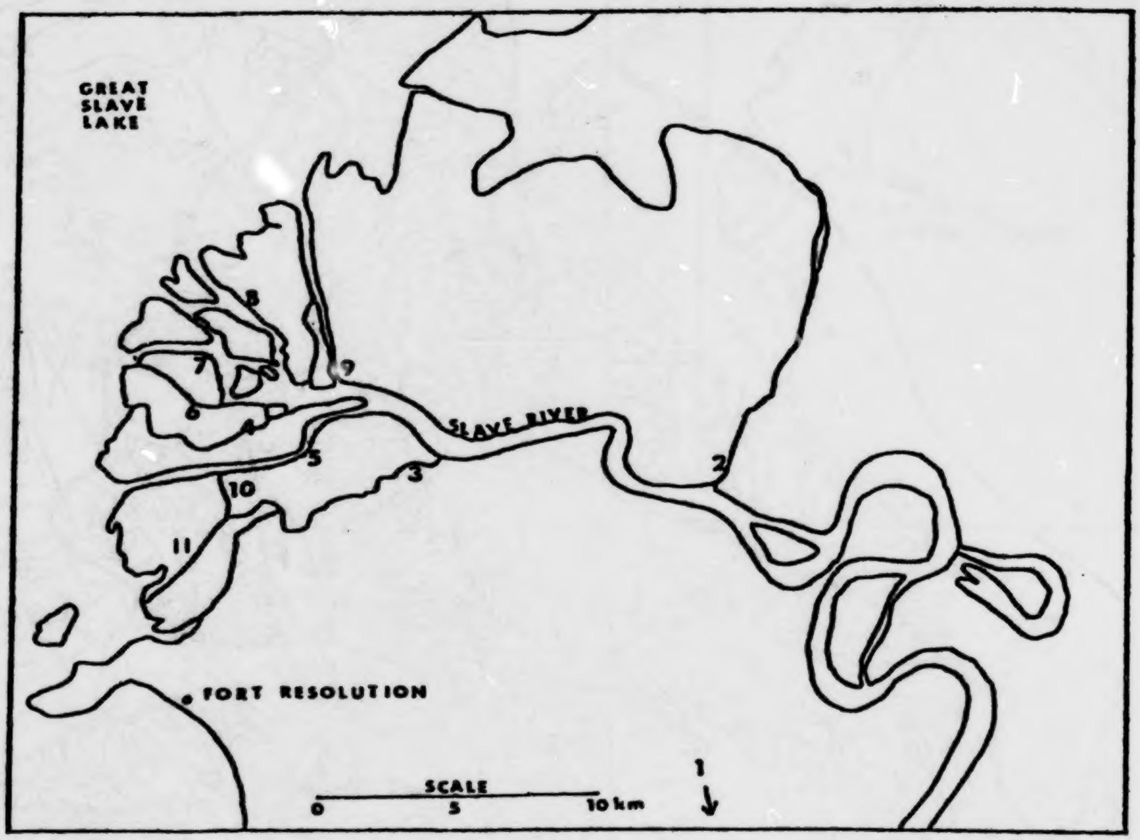
FIGURE 5


Depths in ft.
GREAT SLAVE LAKE
Approx. 100ft depth
Stony Island
Indian Village
MIDDLE CHAN
OLD STEAMBOAT CHAN
Nagle Bay
FORT RESOLUTION
Airfield
Round I
SLAVE RIVER
GAME PRESERVE
RIVER

MAP OF THE SLAVE DELTA, FROM CANADIAN HYDROGRAPHIC SERVICE CHART 6370

SCALE 1:250,000

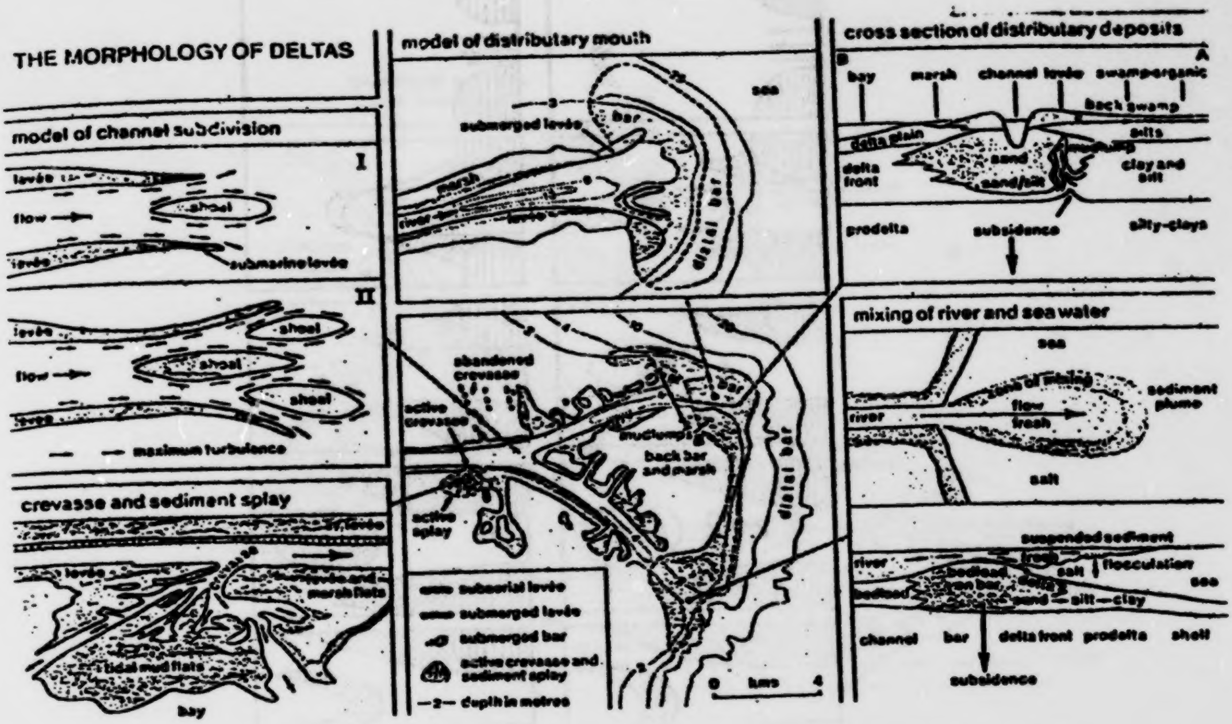
FIGURE 6


GREAT SLAVE LAKE
8
7
9
6
4
5
SLAVE RIVER
10
3
2
11
FORT RESOLUTION
SCALE
0
5
10 km
1

1. Slave River at Bell Rock
2. Jean River below Slave River
3. Nagle Channel below Slave River
4. Slave River West Channel
5. Slave River Old Steamboat Channel near Ft. Resolution
6. Slave River Middle Channel West
7. Slave River Middle Channel East
8. Slave River East Channel
9. Slave River Resdelta Channel
10. Slave River West Channel from Old Steamboat Channel
11. **Sawmill Channel**

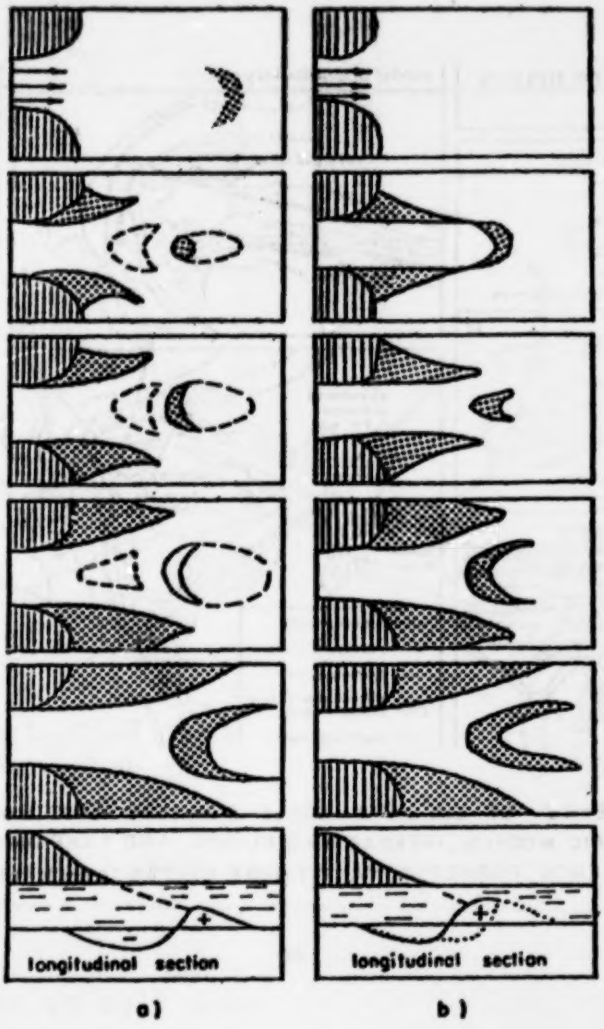
WATER SURVEY OF CANADA GAUGING STATIONS ON DISTRIBUTARY CHANNELS(1970-80)

FIGURE 7


THE MORPHOLOGY OF DELTAS
model of channel subdivision
I
levée
flow
shoal
levée
submarine levée
II
levée
shoal
flow
shoal
shoal
levée
maximum turbulence
crevasse and sediment splay
levée
levée
levée and marsh flats
tidal mud flats
bay
model of distributary mouth
3
submerged levée
bar
sea
marsh
river
levée
distal bar
abandoned crevasse
active crevasse
mudlumps
back bar and marsh
active splay
distal bar
subaerial levée
submerged levée
submerged bar
active crevasse and sediment splay
—2— depth in metres
0 kms 4
cross section of distributary deposits
B
A
bay
marsh
channel levée
swamp organic
back swamp
delta plain
silts
delta front
sand
sand/silt
mudlump
clay and silt
prodelta
subsidence
silty-clays
mixing of river and sea water
sea
zone of mixing
sediment plume
river
flow
fresh
salt
suspended sediment
river
fresh
salt
flocculation
sea
bedload
bedload
river bar
delta
sand — silt — clay
channel
bar
delta front
prodelta
shelf
subsidence

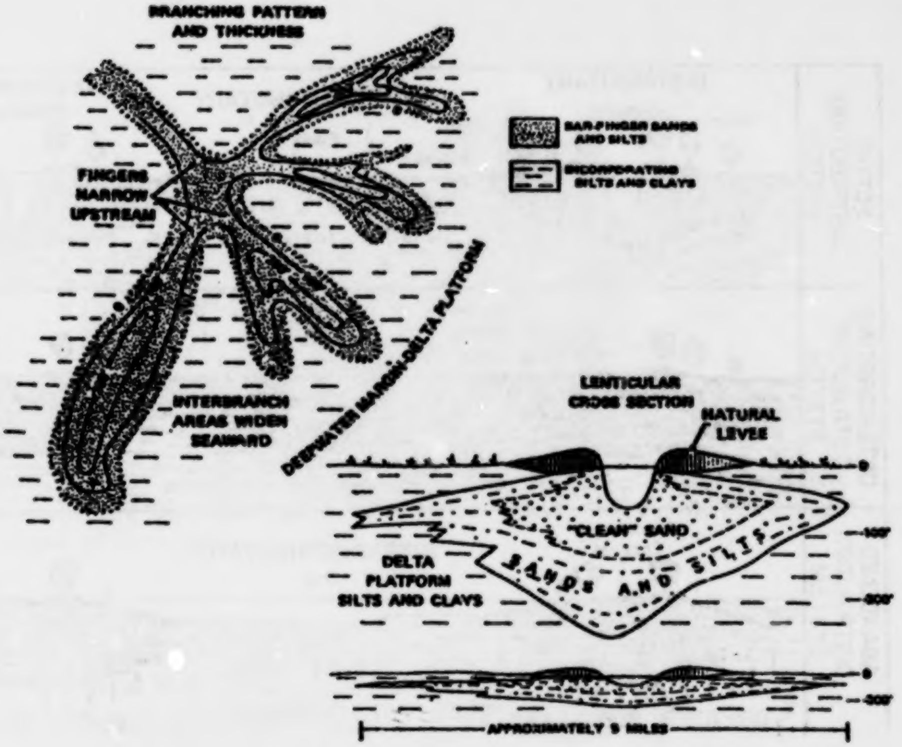
SEQUENCE OF SIX SMALL-SCALE DIAGRAMS ILLUSTRATING THE MORPHOLOGY AND GENETIC MODELS, INTERACTING FLUVIAL AND LAKE OR SEA PROCESSES, AND SEDIMENTS FORMED IN MANY LARGE DELTAS (from Ritchie and Brunsden, p71)

FIGURE 8


longitudinal section
longitudinal section
a)
b)

TWO WAYS IN WHICH BARS FORM IN FRONT OF RIVER MOUTHS. BOTH TYPES OF BAR FORMATION CAN BE SEEN ALONG THE SHORELINE OF THE SLAVE RIVER DELTA (from Thakur and MacKay, p9)

FIGURE 9


BRANCHING PATTERN AND THICKNESS
BAR-FINGER SANDS AND SILTS
INCORPORATING SILTS AND CLAYS
FINGERS NARROW UPSTREAM
INTERBRANCH AREAS WIDEN SEAWARD
DEEPWATER MARGIN-DELTA PLATFORM
LENTICULAR CROSS SECTION
NATURAL LEVEE
"CLEAN" SAND
SANDS AND SILTS
DELTA PLATFORM SILTS AND CLAYS
0
-100'
-200'
0
-200'
APPROXIMATELY 5 MILES

(After Fisk, 1961)

Figure 10 Distinguishing geometric and sedimentary characteristics of bar finger sands. Note that bar finger sands are among the coarsest and cleanest sediments in deltas, and commonly sink into soft underconsolidated underlying delta platform silts and clays (from Gould, p. 29, after Fisk, 1961).

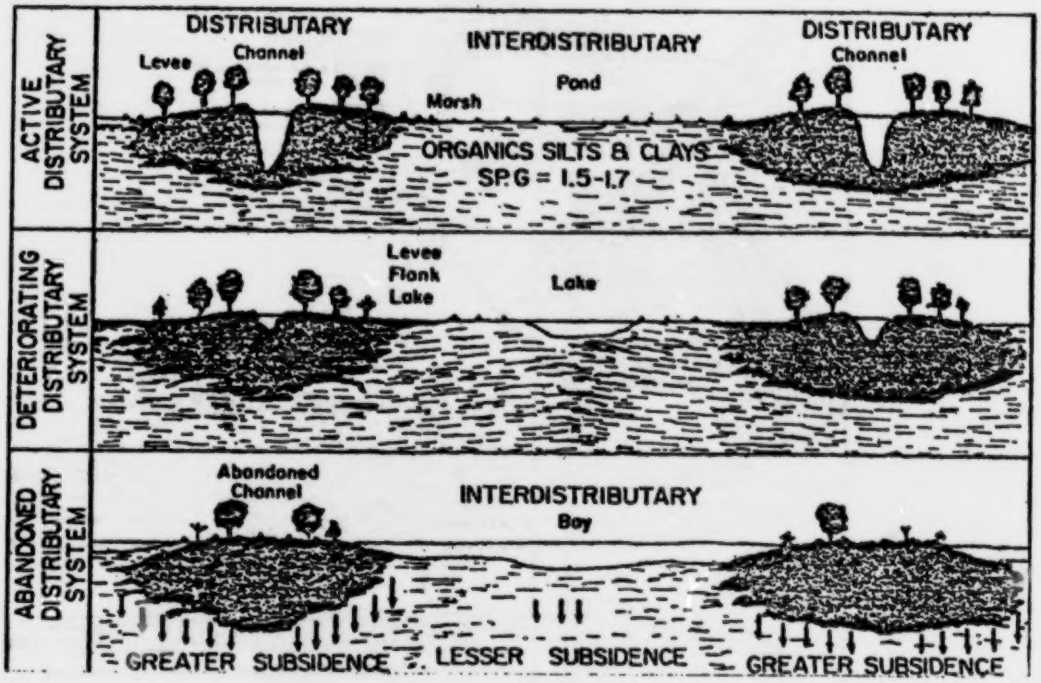

ACTIVE DISTRIBUTARY SYSTEM
DISTRIBUTARY
Levee
Channel
INTERDISTRIBUTARY
Marsh
Pond
DISTRIBUTARY
Channel
ORGANICS SILTS & CLAYS
SP.G = 1.5-1.7
DETERIORATING DISTRIBUTARY SYSTEM
Levee
Flank
Lake
Lake
ABANDONED DISTRIBUTARY SYSTEM
Abandoned
Channel
INTERDISTRIBUTARY
Bay
GREATER SUBSIDENCE
LESSER SUBSIDENCE
GREATER SUBSIDENCE

Figure 11 Effects of deltaic subsidence during distributary system formation and abandonment. Inspection of nine sets of aerial photographs between 1930 and 1979 reveals initially well-expressed levees outlined by better drainage and taller woodland vegetation. As the distributaries are abandoned (i.e. no longer active or only sporadically active), they shrink rapidly in size. They are commonly referred to as moribund serpentine distributaries, as moribund refers to the state of dying or approaching death -- hence shriveling in size. The coarser levees, usually normally consolidated or slightly overconsolidated from desiccation, commonly subside slowly into the soft, usually underconsolidated, organic silts and clays below (from Thakur and Mackay, p. 13).

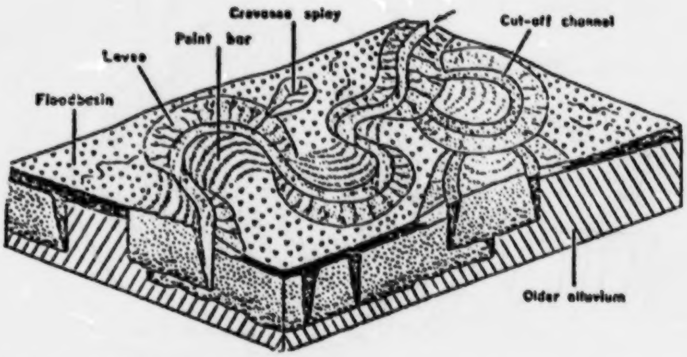

Crevasse splay
Point bar
Levee
Floodbasin
Cut-off channel
Older alluvium

FIGURE 12 Terminology of alluvial deposits formed along a low gradient meandering stream transporting fine sand, silt, and clay particles (from Allen, 1970, p. 141).

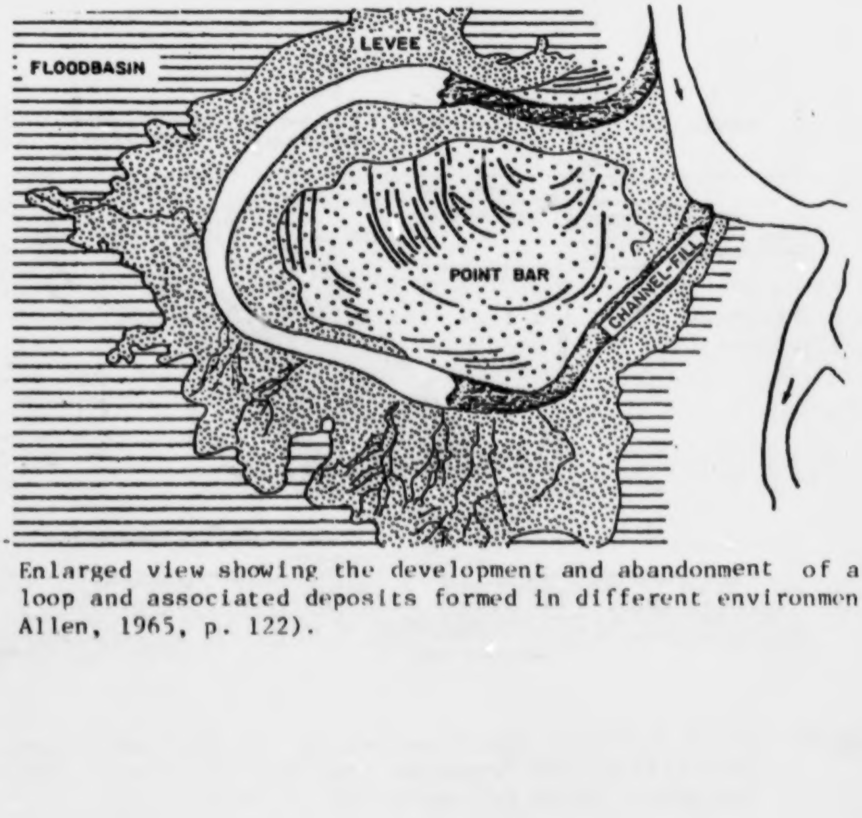

FLOODBASIN
LEVEE
POINT BAR
CHANNEL-FILL

FIGURE 13 Enlarged view showing the development and abandonment of a meander loop and associated deposits formed in different environments (from Allen, 1965, p. 122).

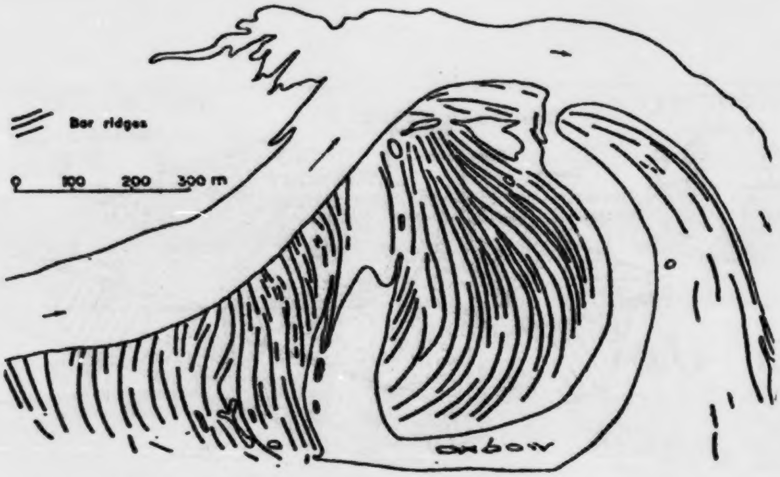

Bar ridges
0 100 200 300 m
oxbow

FIGURE 14 Typical accretion topography on point bars on the scroll plain adjoining the Slave River (from Allen, 1965, p. 116).

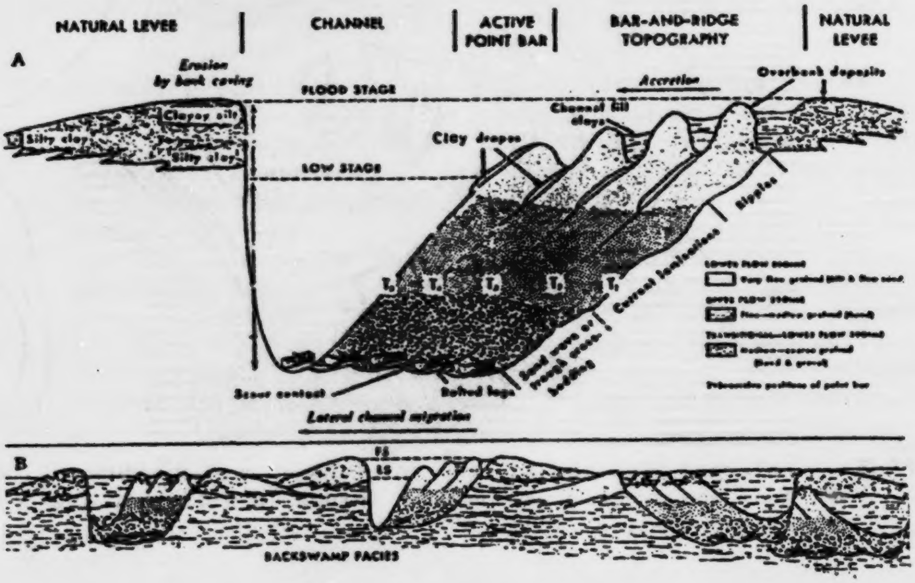
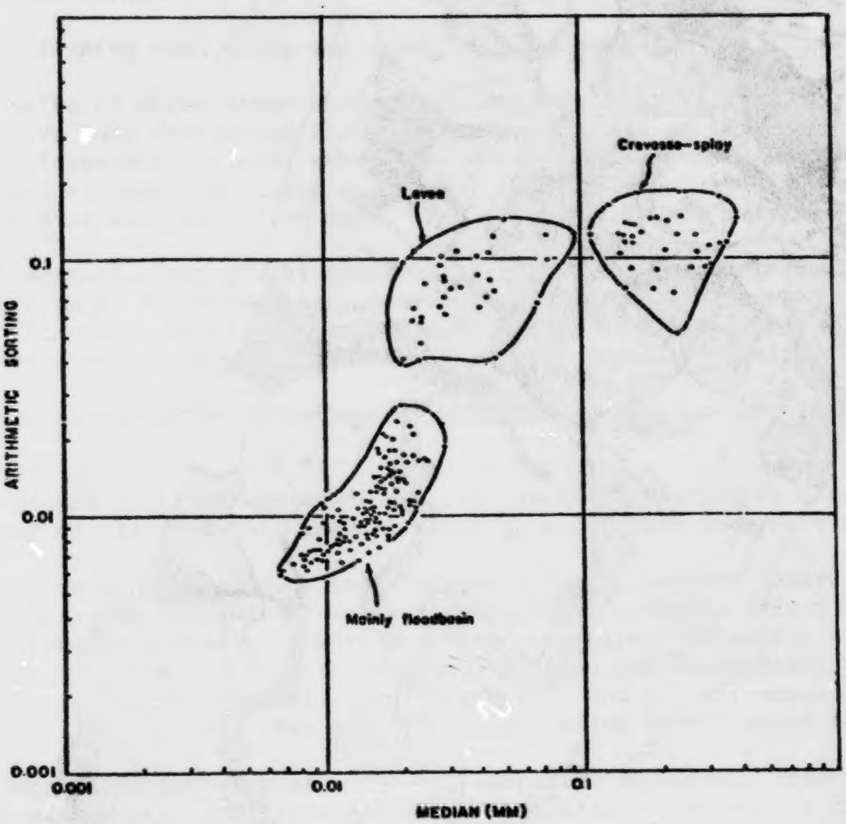
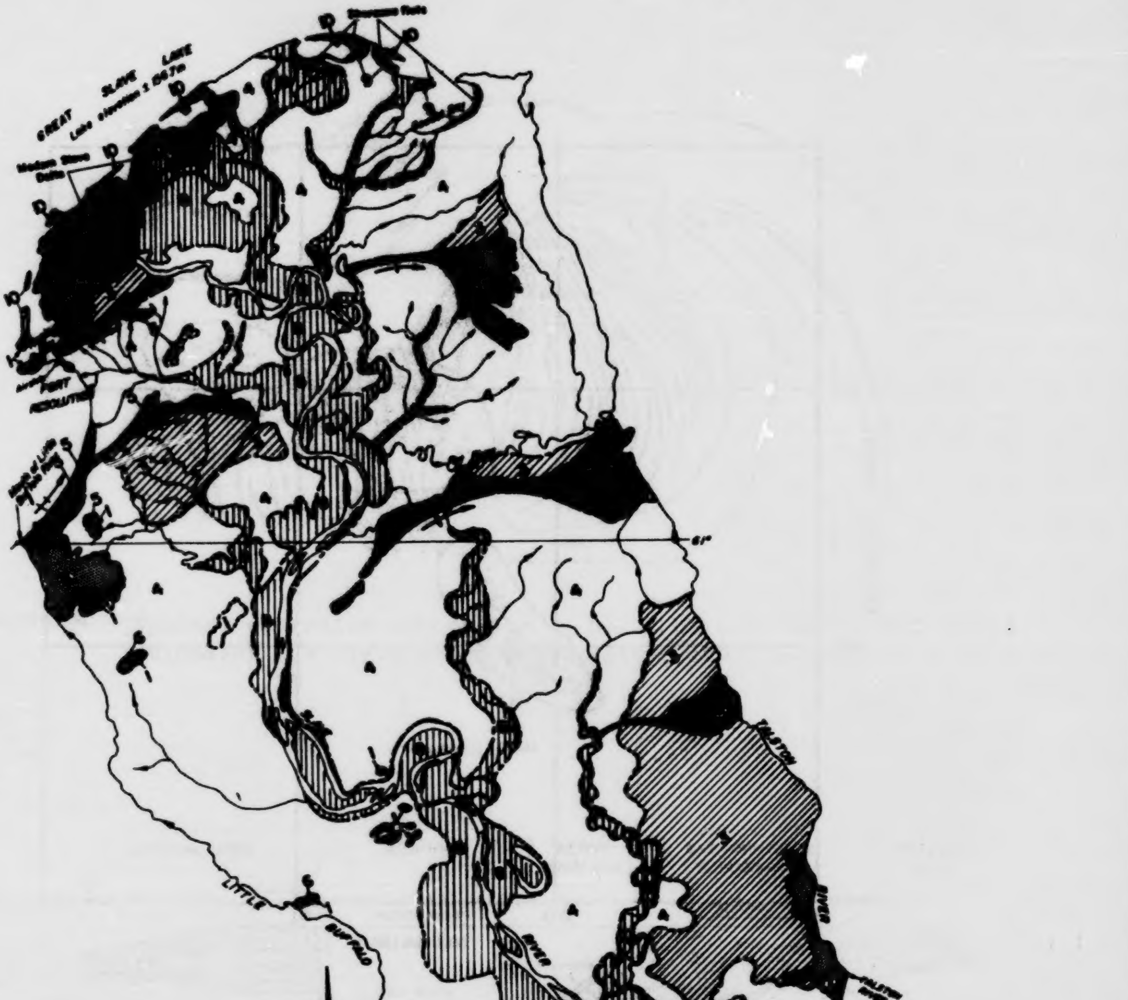

NATURAL LEVEE
CHANNEL
ACTIVE POINT BAR
BAR-AND-RIDGE TOPOGRAPHY
NATURAL LEVEE
A
Erosion by bank caving
FLOOD STAGE
Accretion
Overbank deposits
Clayey silt
Silty clay
Silty clay
Channel fill clays
Clay drapes
LOW STAGE
Ripples
Current laminations
Sand waves or trough cross-bedding
Scour contact
Rolled logs
Lateral channel migration
B
FS
LS
BACKSWAMP FACIES

FIGURE 15 Cross sectional views showing the internal structure, mechanical composition, and formation processes associated with accretional topography (from Orr and Quick, p. 348).



Textural characteristics of topstratum deposits. Note the floodbasin deposits are mostly silt and finer materials, whereas natural levees are silt and very fine sand and crevasse (sediment) splays consist of fine sand (from Allen, 1965, p. 151).

FIGURE 16


GREAT SLAVE LAKE
Lake elevation ± 156.7m
FORT RESOLUTION
61°
LITTLE BUFFALO RIVER
RIVER
TALSTON
TALSTON RIVER
North
60°
NWT
ALBERTA
Elevation ± 160m
FORT SMITH

GEOMORPHOLOGY AND DEPOSITIONAL ENVIRONMENTS
(LANDFORMS AND MATERIALS)
SLAVE RIVER PLAIN AND SLAVE DELTA , NORTHWEST TERRITORIES

See figure 17b for legend

FIGURE 17a

GEOMORPHOLOGY AND DEPOSITIONAL ENVIRONMENTS
(LANDFORMS AND MATERIALS)
SLAVE RIVER PLAIN AND SLAVE DELTA, NORTHWEST TERRITORIES

10 Actively forming sand spits and nearshore sand bars

9 Modern delta of Slave River and beaches and adjoining land below the shore of Great Slave Lake (shorezone flats). The Slave Delta consists of natural levees, sediment (crevasse) splays, subdeltas, active and abandoned distributaries with or without sloughs and marshy and swampy interdistributary floodbasins. Mostly silt and clay with some fine sand. Extensive marshy and swampy wetland

8 Lateral accretion topography (scrolled alluvial plain) adjoining the Slave River and major distributaries, commonly abandoned and branching off the Slave River. Sloughs occupy the lower parts of swales. Mainly fine sand, silt, and clay particles (medium textures) in point bars with organic deposits in swales

7 Low terraces along the Tethul and Talston River valleys. Mostly sand and silty sand

6 Wave-modified platform surrounding raised areas of limestone, with or without a capping of till. Mainly gravelly sand to silty sand (coarse textures)

5 Multiple, raised (abandoned) beach ridges splaying outward toward the east and northeast as a result of waves and longshore currents driven by westerly and northwesterly winds. Reworked deltaic deposits. Temporary abandonment of delta progradation. Alternate shoreline erosion and deposition, with wave and current erosion dominant. Indistinct wave and current eroded scarplets in some places. Mainly fine sand with some medium sand (coarse textures)

4 Lacustrine plain composed of offshore, deepwater deposits. Commonly patterned with abandoned distributaries (moribund serpentine distributary channels). Evidence of past overbank flooding and deposition of postglacial alluvial and lacustrine sediments. Mainly silt and clay with extensive, generally thin, organic deposits at the surface (fine textures)

3 Lacustrine plain composed of nearshore deposits. Mainly fine sand, very fine sand and silt, with scattered patches of organic deposits (medium textures)

2 Raised ("fossil") delta at Fort Smith, built, possibly 10,000 years ago, into glacial Lake McConnell. Mainly fine sand with some medium sand and silt (coarse textures)

1 Small mesalike areas composed of wave-modified limestone bedrock, with or without a capping of glacial till. Former islands in a large lake shrinking in size. Mainly gravelly sand

GRAPHICAL SYMBOLS

→ Direction of longshore current (shown on landward side of raised beach ridges)(unit 5)

⤳ Direction of generally east-west serpentine creek channels; located basinward and roughly parallel to multiple raised beach ridges

⇶ Location of discontinuous abandoned distributary channels, originating from overbank flooding of the Slave River

FIGURE 17b

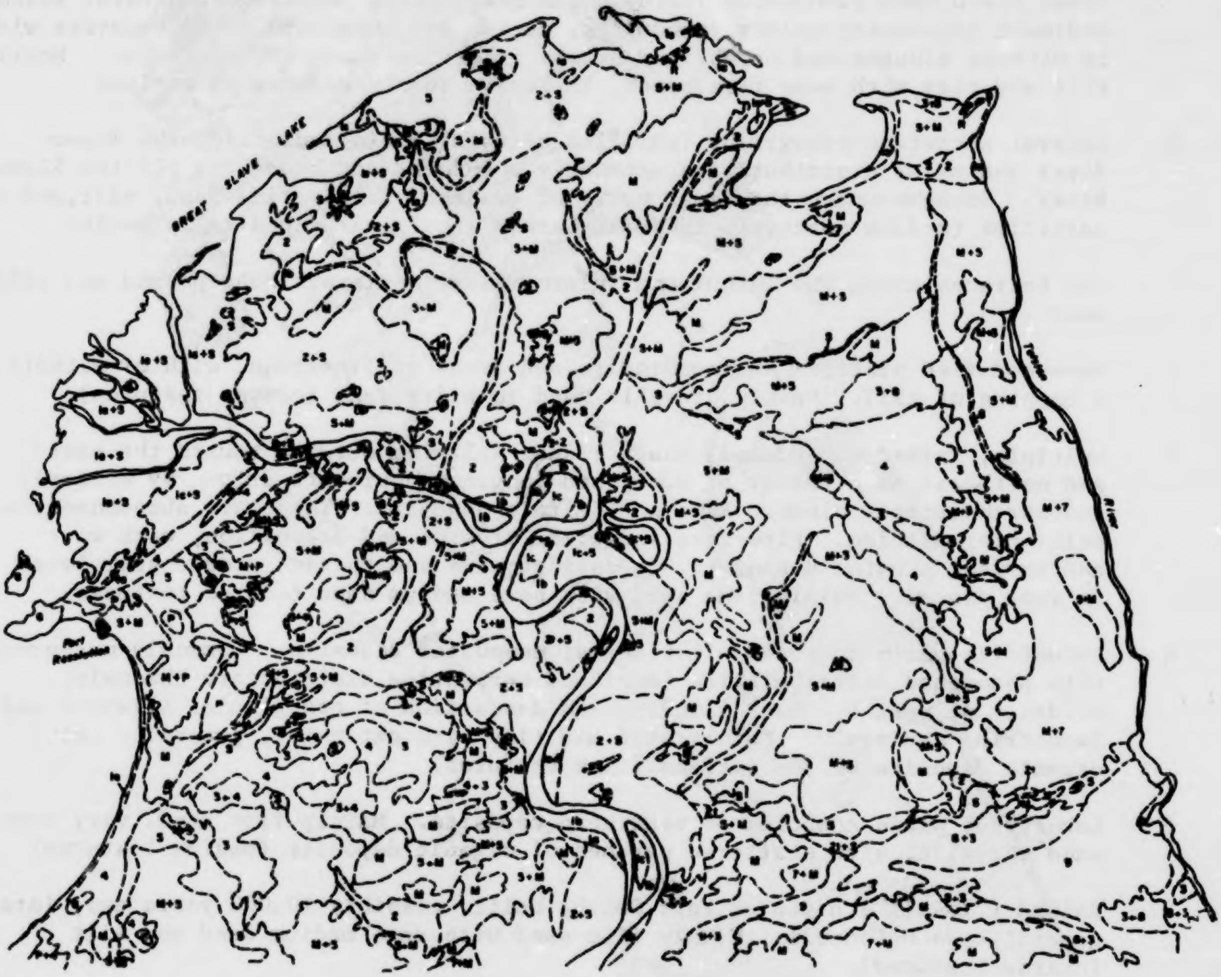

GREAT SLAVE LAKE
Fort Resolution

FIGURE 18

GEOMORPHOLOGY AND VEGETATION
(A BIOPHYSICAL CLASSIFICATION OF SLAVE DELTA REGION)

Map unit number	Description (landform and topography, soil materials, drainage, permafrost, vegetation)
1a	Modern subaerial portion of delta plain, including shoreland. Level to depressional. Many distributaries(active and abandoned) with sloughs. Variable textures: stratified silt and clay with some fine sand.* Near surface deposits contain organic-rich layers. Locally well to mostly poorly and very poorly drained, depending on microrelief.** Little or no permafrost. Wet and dry sedge meadows, willow-alder brush, and black poplar depending on drainage and relief
1b	Modern floodplain adjoining the Slave River and the Jean River. Level to gently undulating. Low ridges and curvilinear swales. Scrolls. Variable textures: stratified fine sand, silt, clay (loamy sand to silty clay loam). Recent alluvial soils containing organic-rich layers. Mostly well drained. Willow-alder brush and black poplar. Generally willow on lower terraces and shoals, alder on middle terraces,and balsam poplar on higher terraces
1c	Modern floodplain; slightly elevated above 1b. Recent alluvium. Level with curvilinear swales (sloughs). Scroll pattern. Medium to moderately fine textures. Flooded infrequently. Moderately well drained (i.e. elevated above Slave River). Permafrost occurs at about 90 cm. Relatively little thermokarst development. Large white spruce and balsam poplar with alder
2	"Older" lateral accretion ridge deposits (pointbars), separated by curvilinear marshy swales (sedge/grass meadows) and sloughs. Scroll pattern microrelief on these alluvial deposits. Medium to moderately fine textures. Well drained on ridges to very poorly drained in swales. Permafrost at about 60 cm in all better drained soils; thawed beneath linear wet meadow depressions. Minor thermokarst development. White spruce and balsam poplar on pointbar ridges, some alder and white birch with willow shrubs and sedges in poorly drained depressions
2t	Same landform and deposits as 2 but lacking permafrost (thawed)

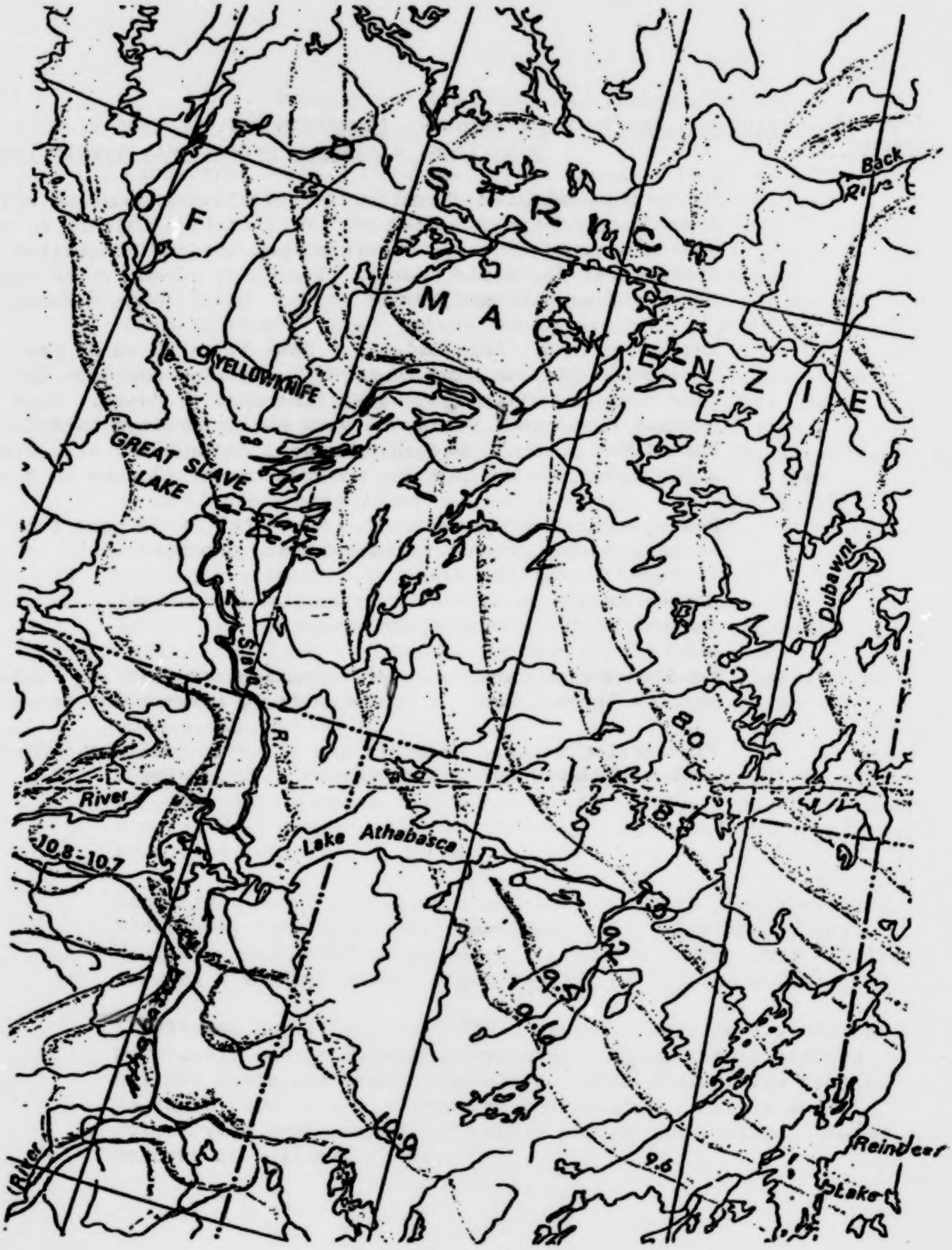
---

*Note: Almost all soils have calcareous parent materials.

** Note: The modern delta surface is generally less than about 3 m above average river level and is therefore flooded frequently.

Map unit number	Description (landform and topography, soil materials, drainage, permafrost, vegetation)
3	Lacustrine basin (overbank flood basin). Level to slightly depressional. Medium textures:fine sandy to silty loams. Transitional between sandy (4 or 9) and clayey (5 or 7) map units. Thin peaty surface. Poorly to very poorly drained. Little or no permafrost. Relatively minor thermokarst development. Birch and willow brush with dwarf shrubs and sedge meadows; black spruce and tamarack in places
4	Lacustrine deltaic/raised beach ridge/crevasse splay. Level to low ridges (gently undulating). Coarse textures: loamy sand to sandy loam. Imperfectly to very poorly drained. Widespread discontinuous permafrost at 30 to 90 cm. Thermokarst is variable; extensive to very little thermokarst. Better drained areas have aspen and white spruce. Willow, black poplar, black spruce and tamarack in poorly drained areas with sedge and grass meadows in collapse scars
5	Lacustrine basin (overbank flood basin). Level to very gently undulating or sloping. Moderately fine textures: silty clay loam . Imperfectly drained. Widespread discontinuous permafrost. Extensive thermokarst development. White spruce, black spruce, tamarack, black poplar, shrub, mosses, and lichens
6	Wave-washed limestone bedrock and gravels over till. Gently to moderately sloping. Coarse textures: gravelly sand, locally stony. Well drained. No permafrost. Aspen and white spruce, some pine locally
7	Lacustrine basin (overbank flood basin). Very gently sloping. Moderately fine textures: clay loam, silty clay loam. Well drained. Scattered permafrost. Extensive thermokarst. White spruce, trembling aspen, black poplar, willow and birch
8	Lacustrine basin (overbank flood basin). Very gently undulating. Moderately coarse to medium textures. Transitional between deltaic sands and lacustrine clays. Well drained low knolls. Sporadic permafrost. Extensive thermokarst. Mainly white spruce with some aspen, and balsam poplar and willows. Sedge meadows in collapse scars.

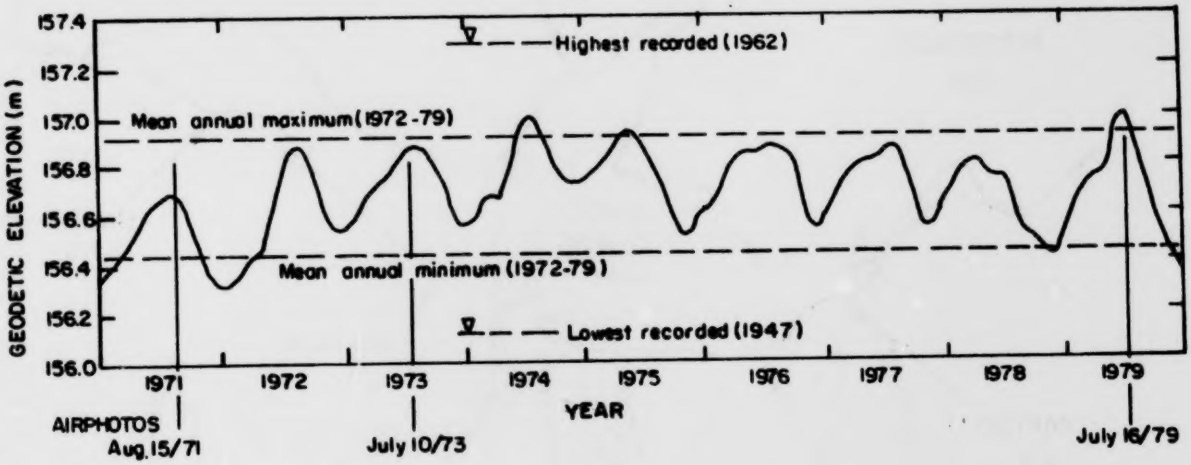
Map unit number	Description (landform and topography, soil materials, drainage, permafrost, vegetation)
9	Lacustrine-deltaic. Level to gently sloping. Coarse textures: loamy sand to fine sandy loam. Well drained (highs) to very poorly drained (lows). Scattered permafrost. Extensive thermokarst (collapse scars). Trembling aspen, white spruce, black poplar, willows, dwarf shrub. Small sedge meadows
M	Marshy wetland. Depressional. Some 15 to 30 cm of peat over moderately fine to fine textured lacustrine deposits (silty clay loam and silty clay) over fine sand at depth. Poor surface drainage. Poorly to very poorly drained internally. Permafrost absent. Sedges, grasses, and rushes; scattered willow clumps. Habitat for muskrat around sloughs in M unit
P	Peaty wetland. Depressional. More than 30 cm peat from sedges, rushes, mosses and wood over moderately fine to fine textured lacustrine deposits. Usually saturated. Widespread discontinuous permafrost. Extensive thermokarst. Sedges, rushes, willow, dwarf birch, mosses
S	Ponded water in abandoned distributary channels and small shallow lakes. Habitat for waterfowl, muskrat,and beaver
R	Precambrian rocks. Granitic and granitic gneisses. Mostly west of Talston Bay and southwest of Grant Point


DISTRICT OF MACKENZIE
YELLOWKNIFE
GREAT SLAVE LAKE
Back River
Dubawnt
Slave R.
River
10.8-10.7
Lake Athabasca
8.0
9.5
9.6
Reindeer Lake
River

Retreat of the Wisconsin ice margin in vicinity of the Slave River delta. Inferred position of retreating ice margin is given in thousands of radiocarbon years BP (before present). After Map 1257A by V.K. Prest, Geological Survey of Canada 1969. Scale: 1:5,000,000.

FIGURE 19

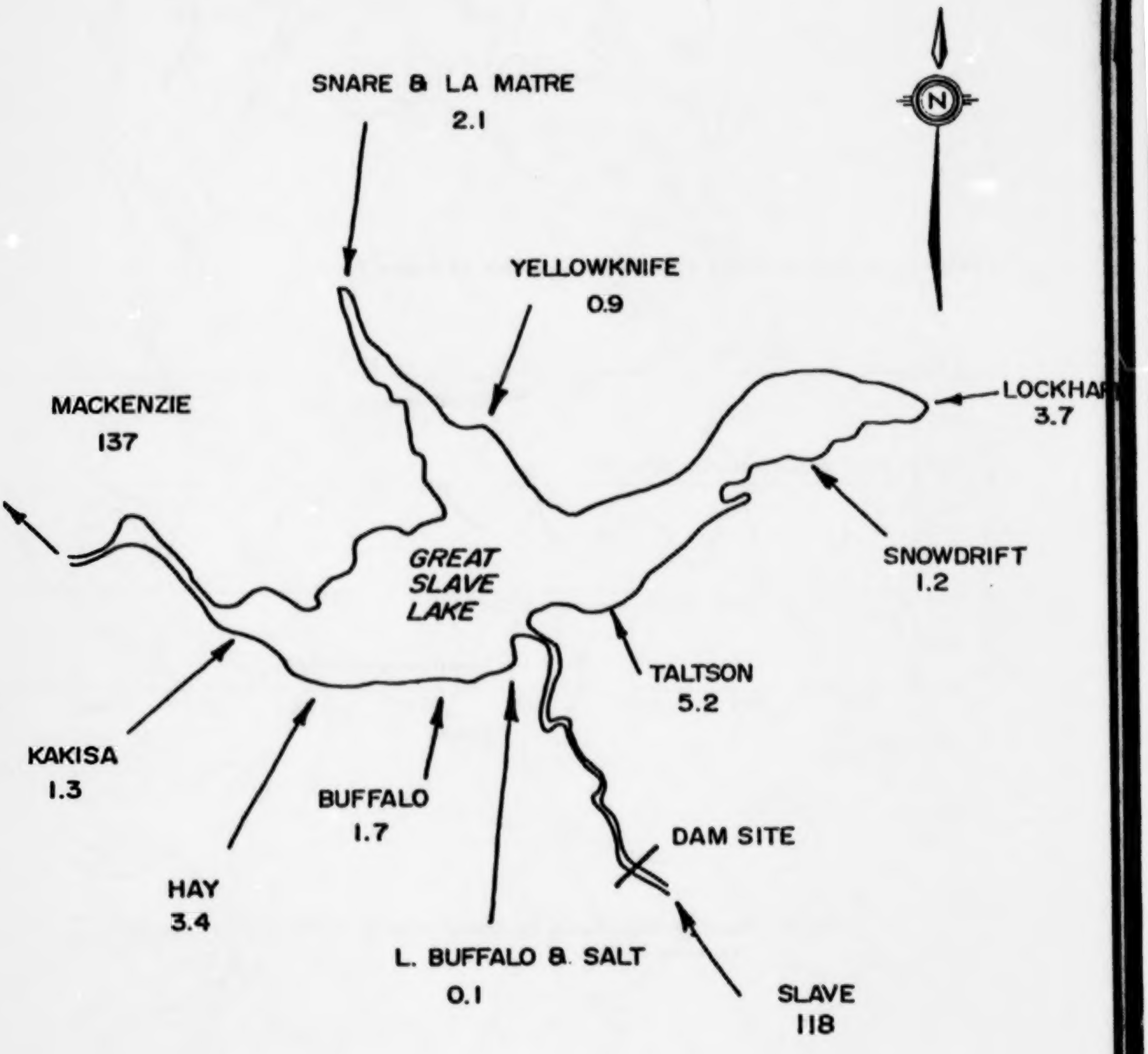
1968 – 72 affected by filling of Williston Reservoir on Peace River



NOTE: Based on Water Survey of Canada records for Great Slave Lake at Yellowknife Bay

MONTHLY WATER LEVELS IN GREAT SLAVE LAKE, 1971 – 79

FIGURE 20

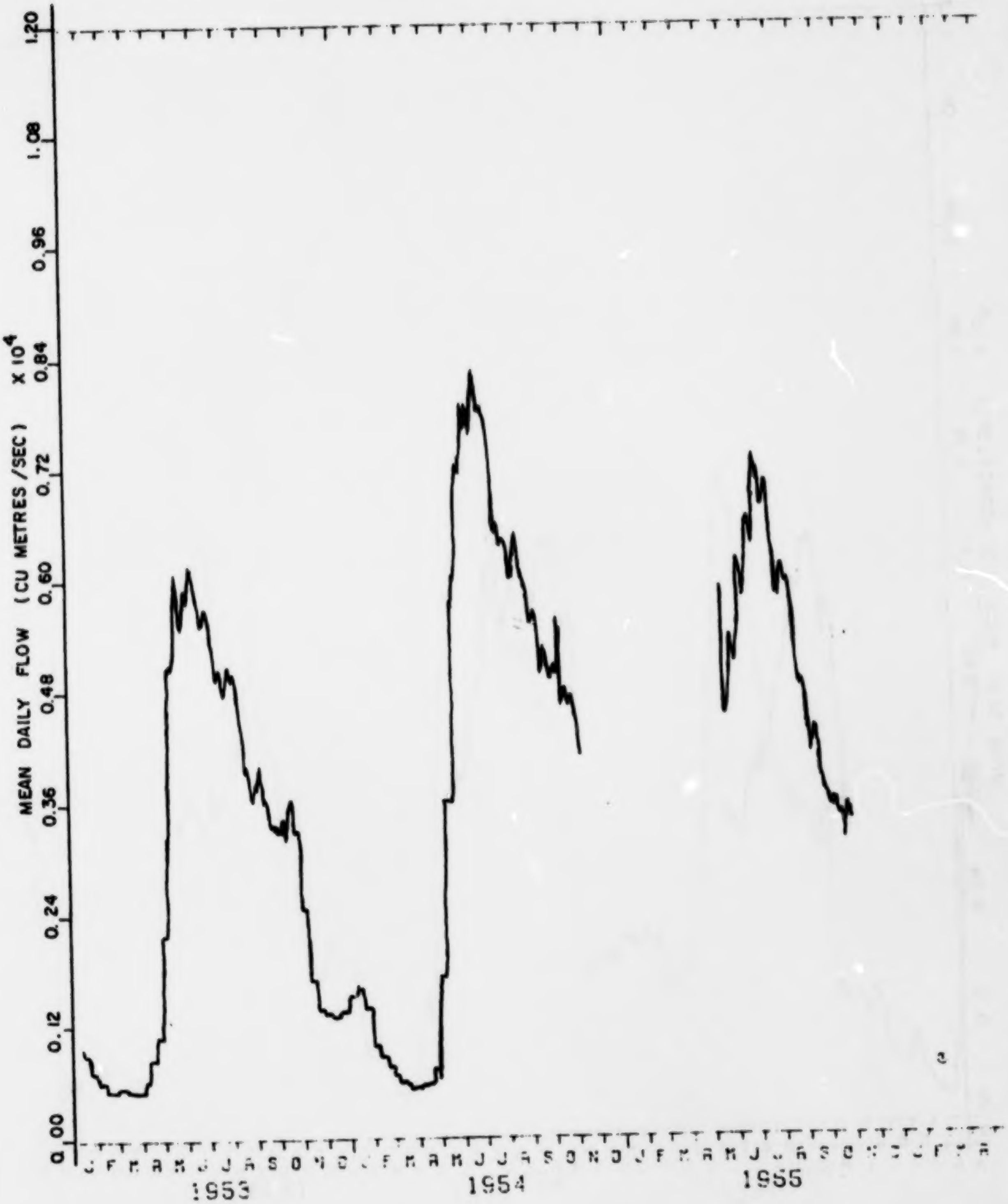

SNARE & LA MATRE
2.1
YELLOWKNIFE
0.9
N
LOCKHA
3.7
MACKENZIE
137
GREAT SLAVE LAKE
SNOWDRIFT
1.2
TALTSON
5.2
KAKISA
1.3
BUFFALO
1.7
DAM SITE
HAY
3.4
L. BUFFALO & SALT
0.1
SLAVE
118

NOTE: UNITS ARE IN km^3/year

MEAN WATER BALANCE FOR GREAT SLAVE LAKE

FIGURE 21

NOTE: DATA RECORDED BY WATER SURVEY OF CANADA, GAUGING STATION 07NB001, SLAVE RIVER AT FITZGERALD

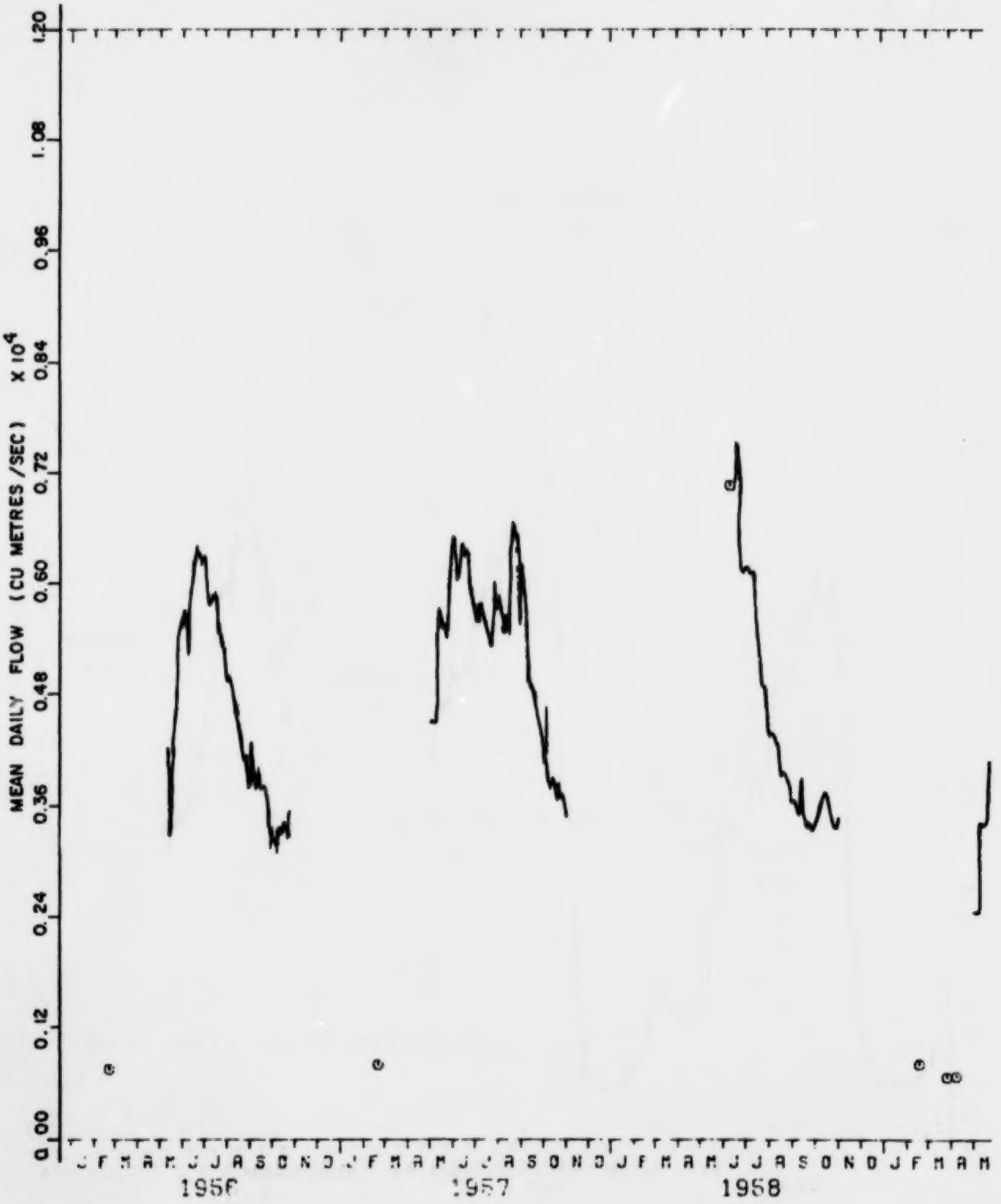


SLAVE RIVER DISCHARGE HYDROGRAPH, 1953-78

Page 1 of 9

FIGURE 22

NOTE: **DATA RECORDED BY WATER SURVEY OF CANADA, GAUGING STATION 07NB001, SLAVE RIVER AT FITZGERALD**

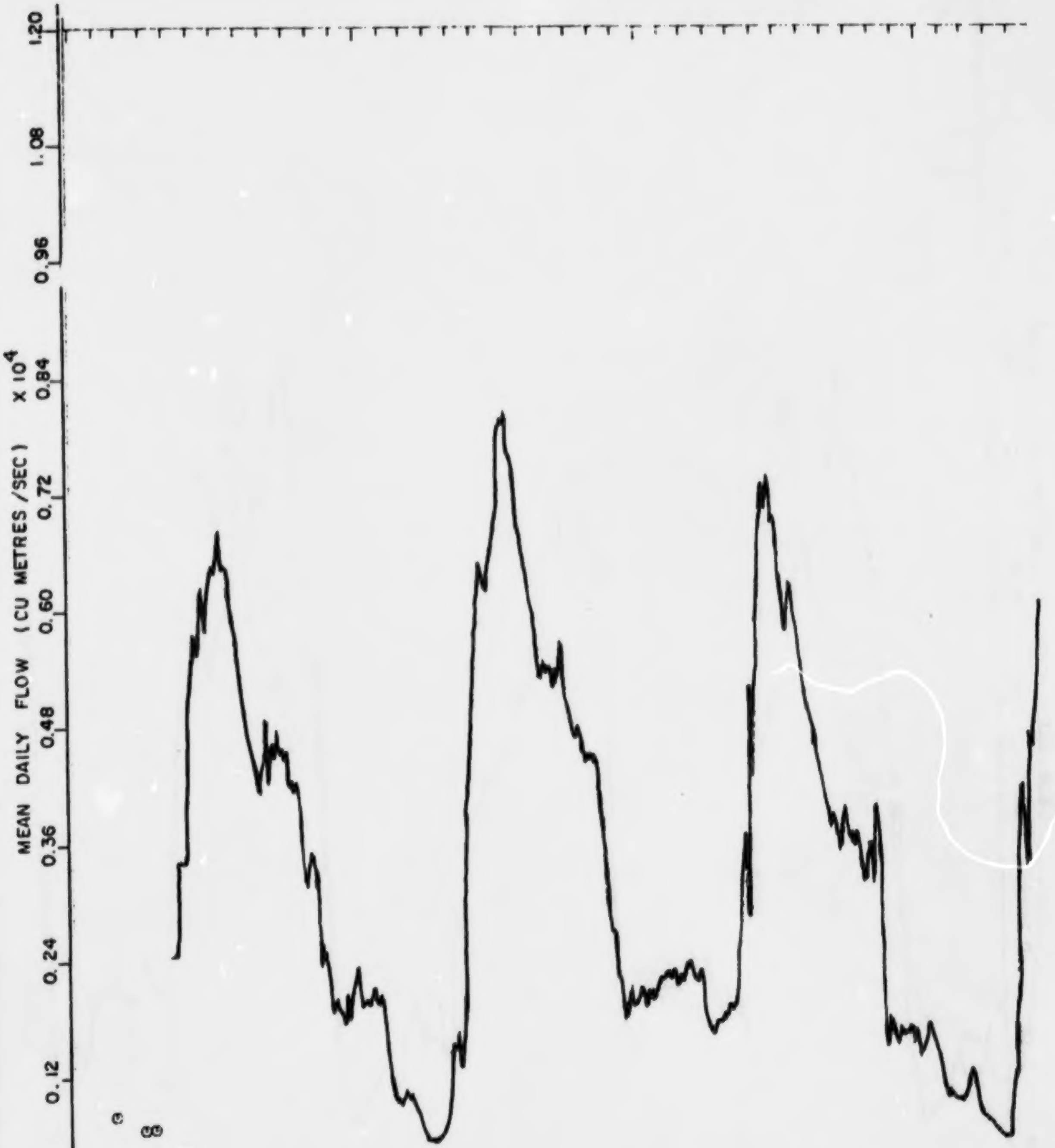


SLAVE RIVER DISCHARGE HYDROGRAPH, 1953-78

Page 2 of 9

FIGURE 22

NOTE: DATA RECORDED BY WATER SURVEY OF CANADA, GAUGING STATION 07NB001, SLAVE RIVER AT FITZGERALD

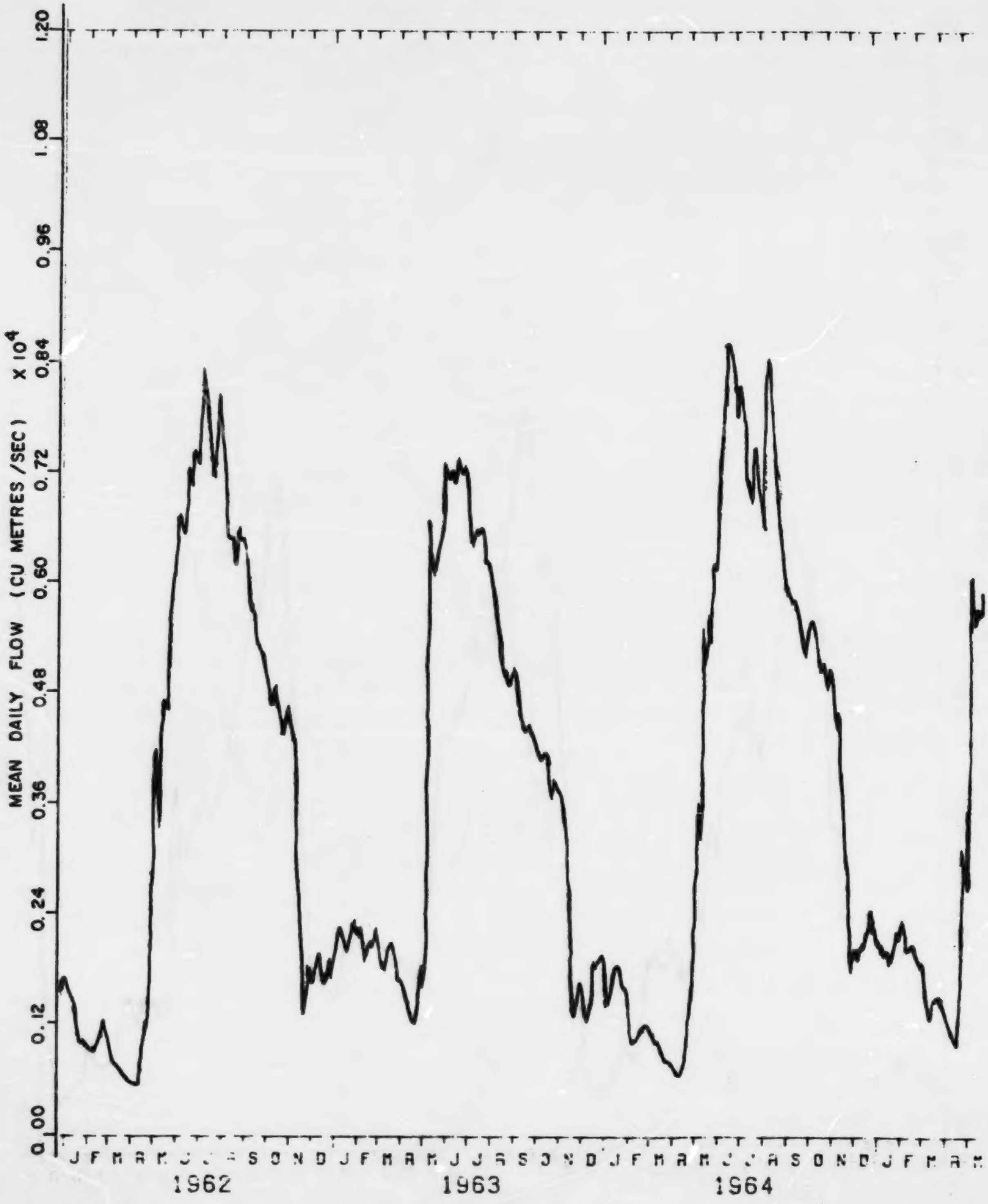


SLAVE RIVER DISCHARGE HYDROGRAPH, 1953-78

Page 3 of 9

FIGURE 22

NOTE: DATA RECORDED BY WATER SURVEY OF CANADA, GAUGING STATION 07NB001, SLAVE RIVER AT FITZGERALD

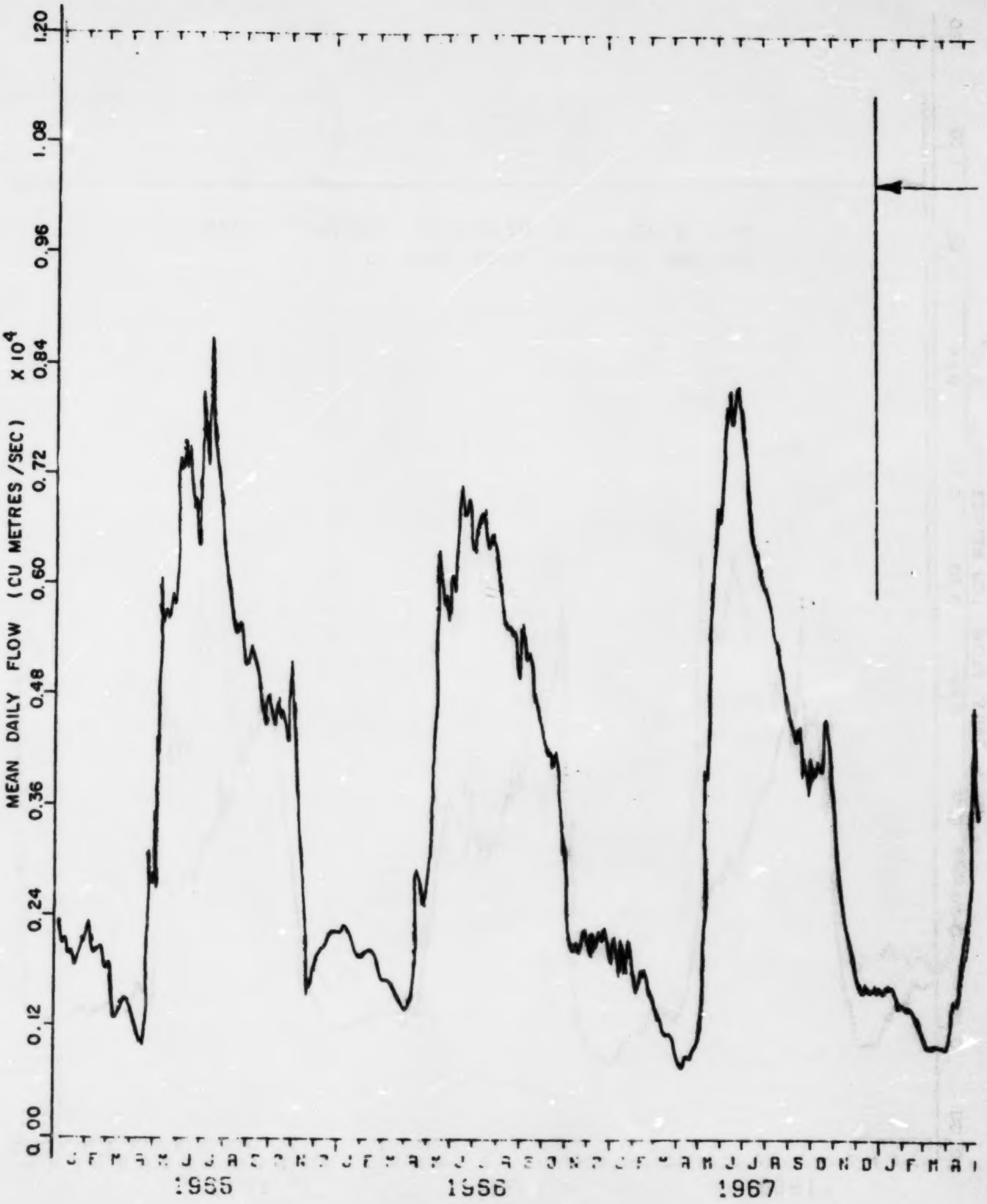


SLAVE RIVER DISCHARGE HYDROGRAPH, 1953-78

Page 4 of 9

FIGURE 22

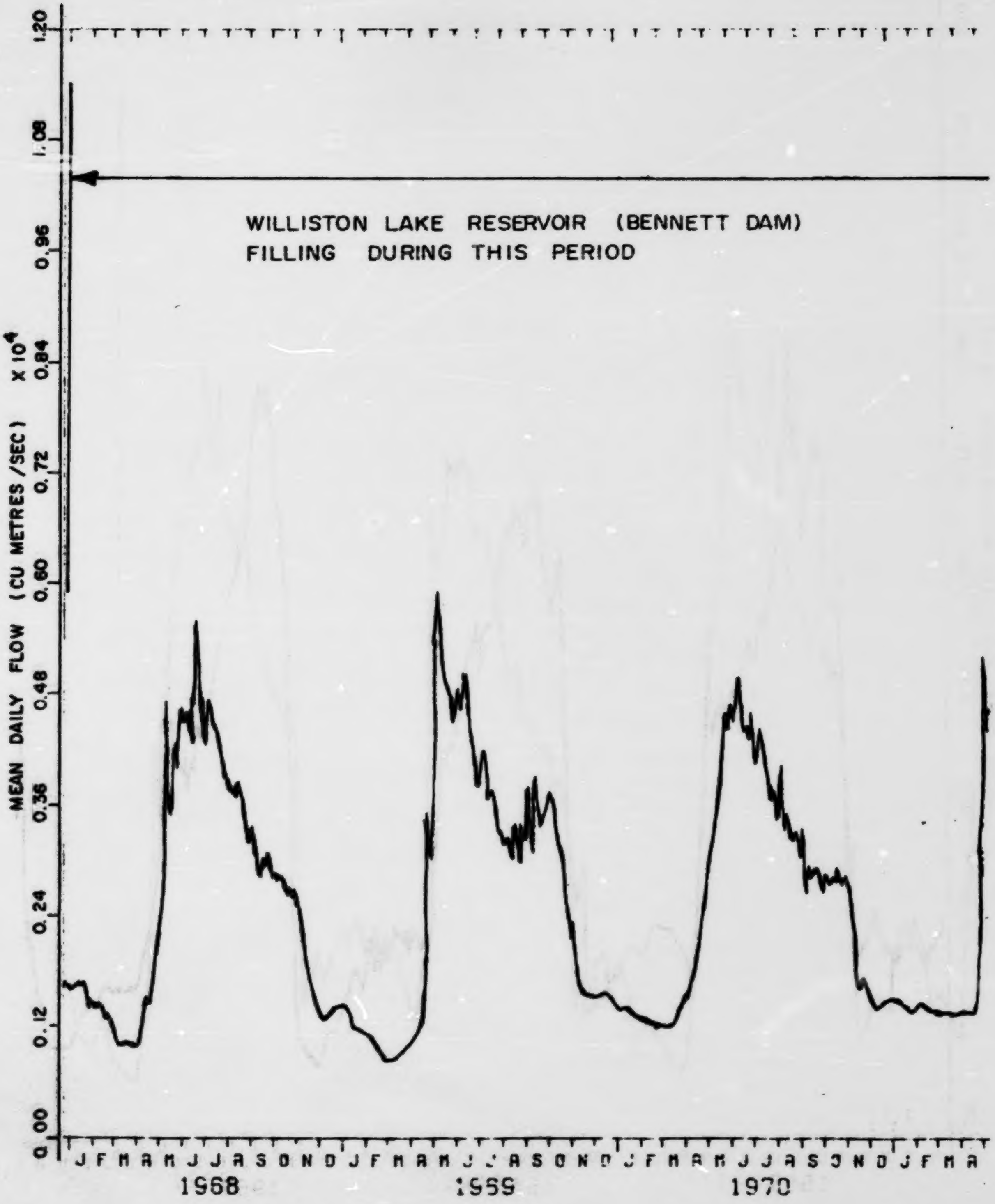
NOTE: DATA RECORDED BY WATER SURVEY OF CANADA, GAUGING STATION 07NB001, SLAVE RIVER AT FITZGERALD



SLAVE RIVER DISCHARGE HYDROGRAPH, 1953-78

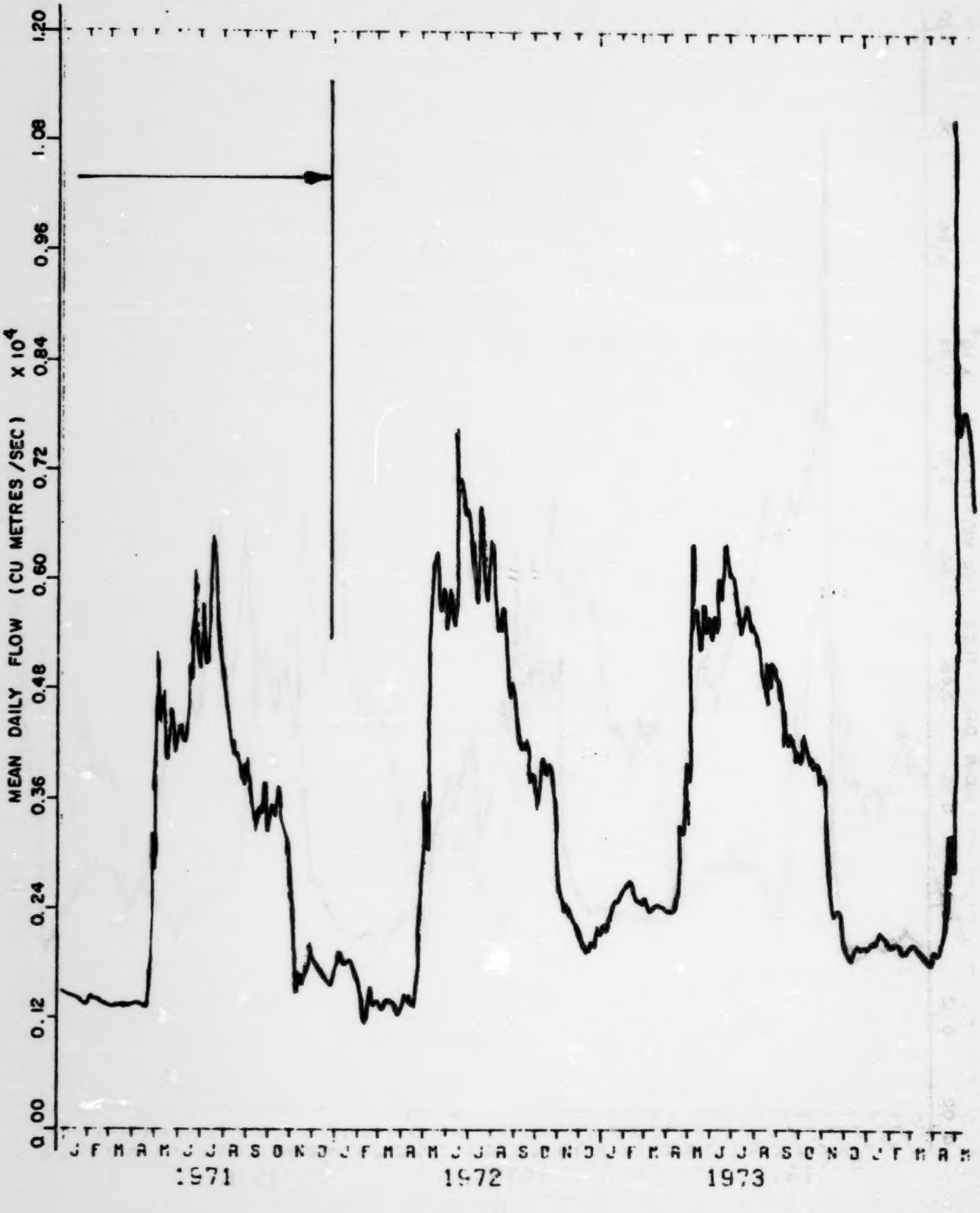
FIGURE 22

NOTE: **DATA RECORDED BY WATER SURVEY OF CANADA, GAUGING STATION 07NB001, SLAVE RIVER AT FITZGERALD**



SLAVE RIVER DISCHARGE HYDROGRAPH, 1953-78

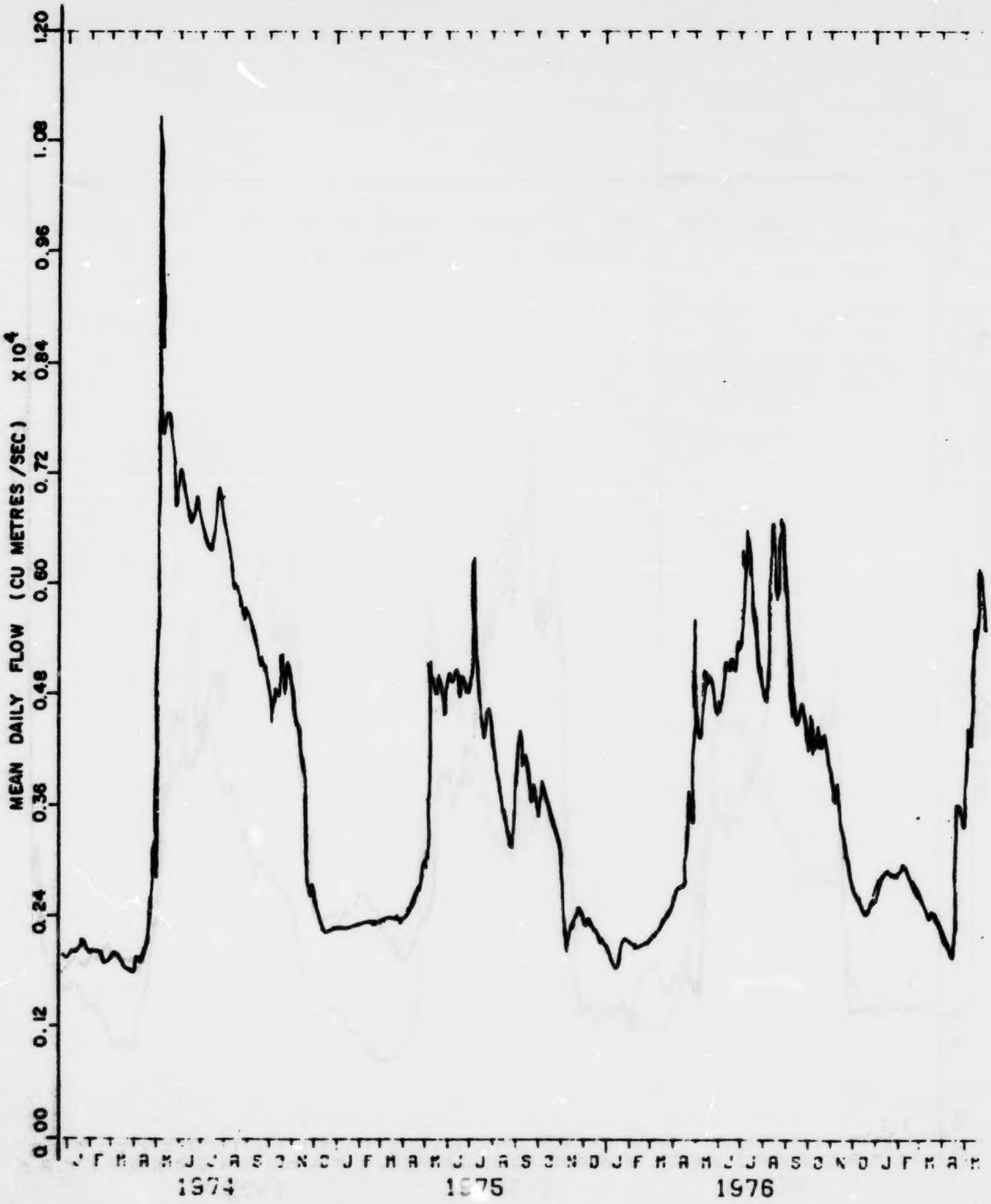
NOTE: **DATA RECORDED BY WATER SURVEY OF CANADA, GAUGING STATION 07NB001, SLAVE RIVER AT FITZGERALD**



SLAVE RIVER DISCHARGE HYDROGRAPH, 1953-78

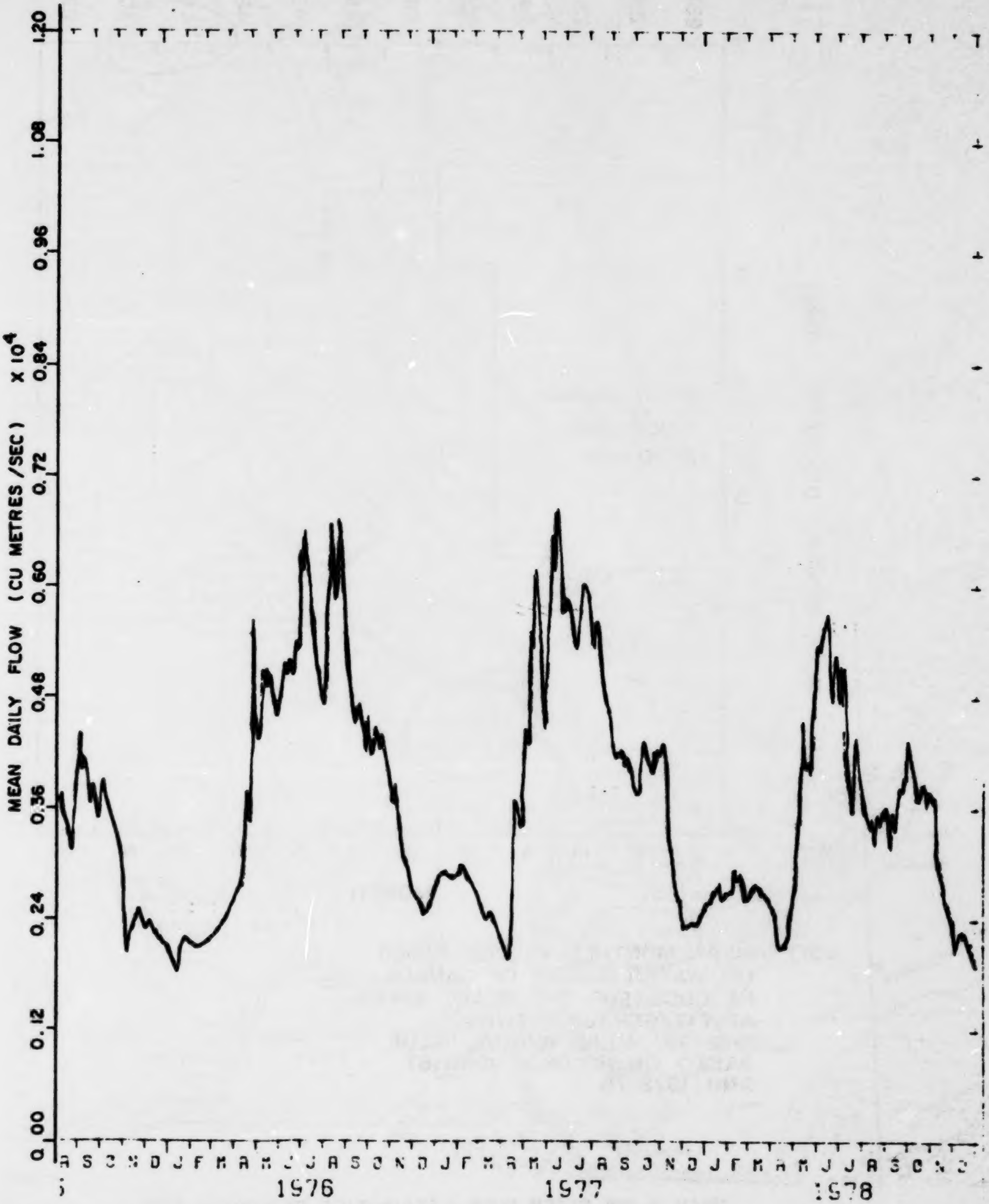
FIGURE 22

NOTE: DATA RECORDED BY WATER SURVEY OF CANADA, GAUGING STATION 07NB001, SLAVE RIVER AT FITZGERALD



SLAVE RIVER DISCHARGE HYDROGRAPH, 1953-78

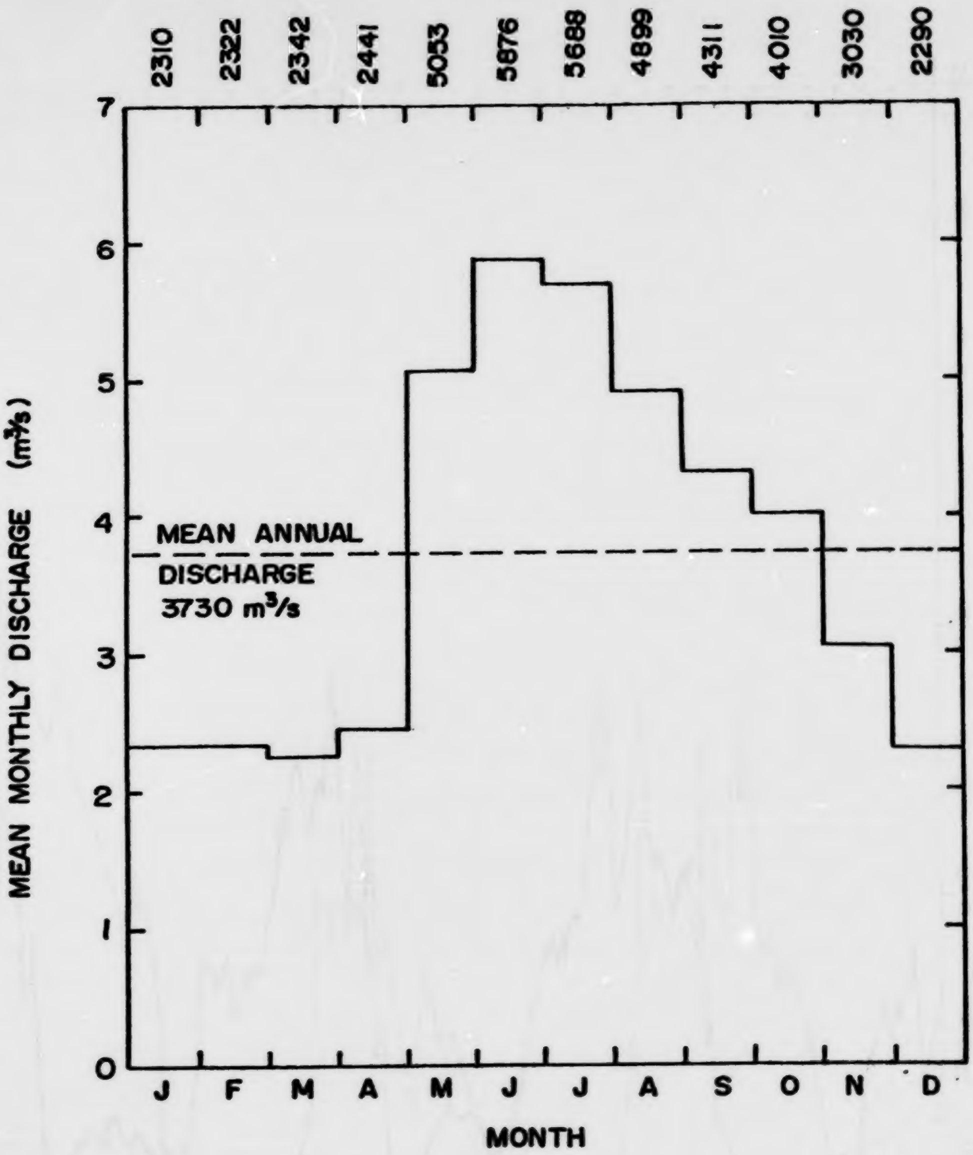
NOTE: DATA RECORDED BY WATER SURVEY OF CANADA, GAUGING STATION 07NB001, SLAVE RIVER AT FITZGERALD



SLAVE RIVER DISCHARGE HYDROGRAPH, 1953-78

Page 9 of 9

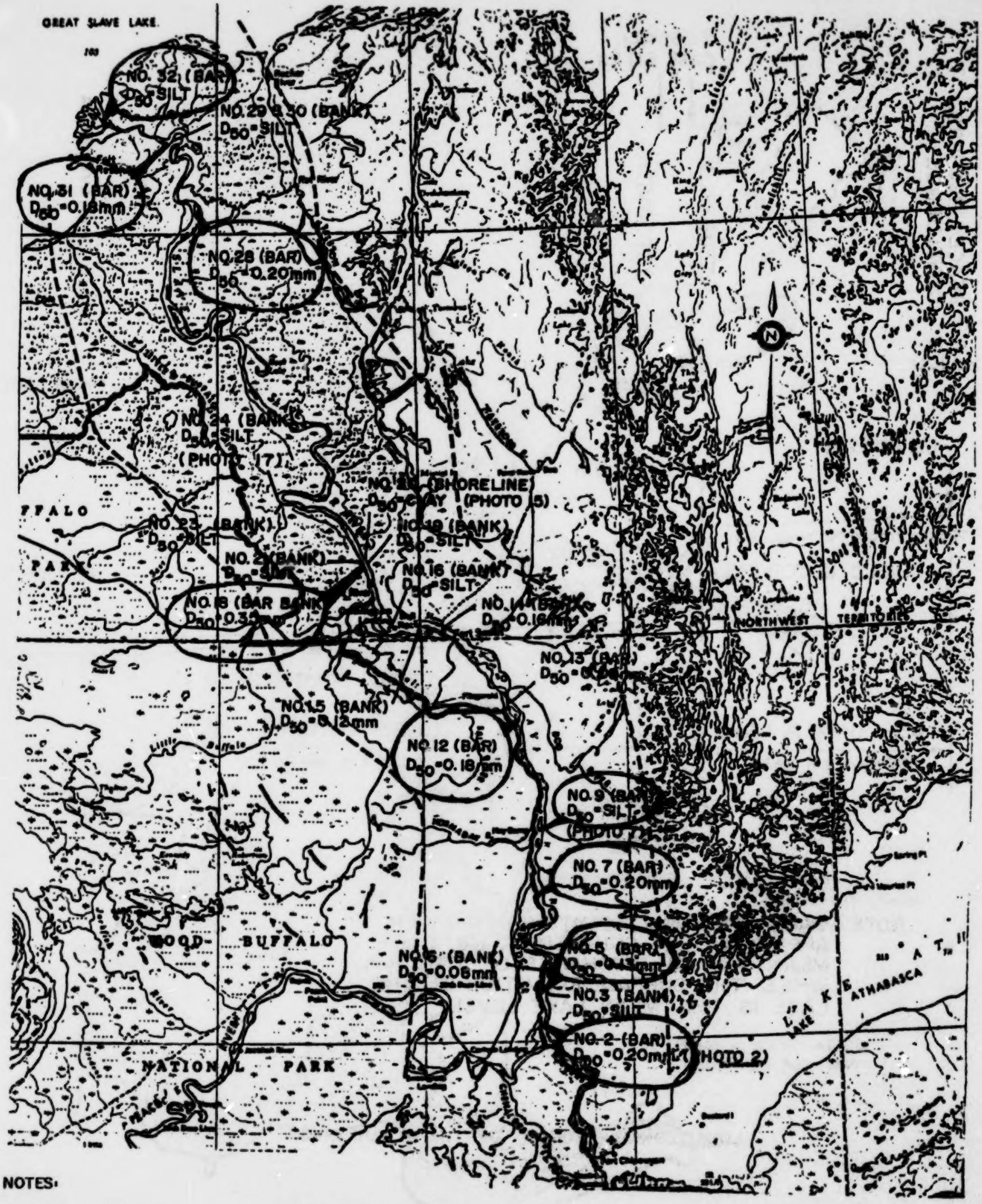
FIGURE 22



NOTE: MEAN MONTHLY VALUES BASED ON WATER SURVEY OF CANADA RECORDS FOR THE SLAVE RIVER AT FITZGERALD (07NB001) 1972-79, MEAN ANNUAL VALUE BASED ON RECORDS 1960-67 AND 1972-79

MEAN SLAVE RIVER FLOW DISTRIBUTION BY MONTHS FOR POST - BENNETT DAM PERIOD, 1972-79

FIGURE 23

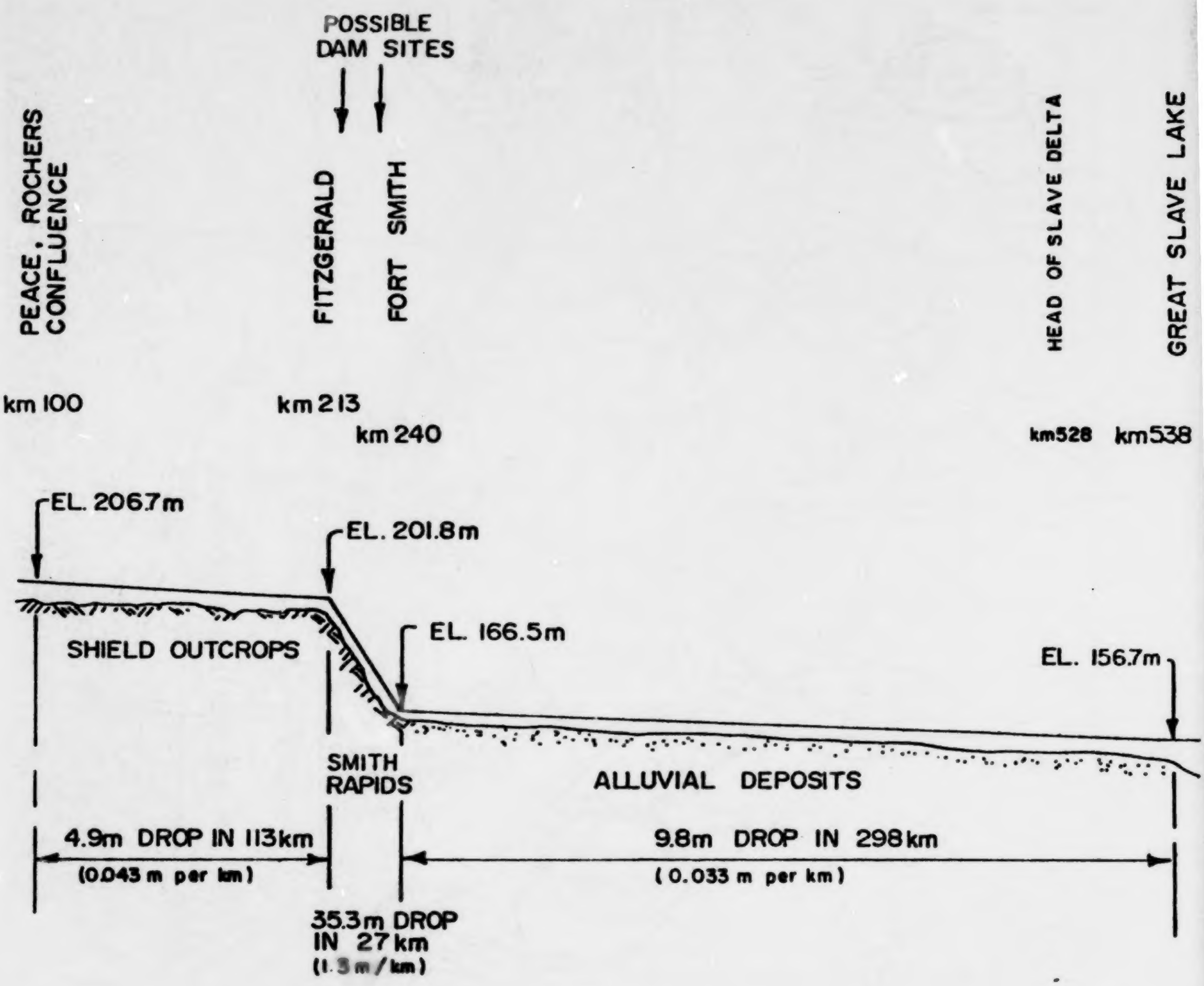

GREAT SLAVE LAKE
NO. 32 (BAR) D50=SILT
NO. 29 & 30 (BANK) D50=SILT
NO. 31 (BAR) D50=0.18mm
NO. 28 (BAR) D50=0.20mm
NO. 24 (BANK) D50=SILT (PHOTO 17)
NO. 25 (SHORELINE) D50=CLAY (PHOTO 15)
NO. 23 (BANK) D50=SILT
NO. 19 (BANK) D50=SILT
NO. 21 (BANK) D50=SILT
NO. 16 (BANK) D50=SILT
NO. 18 (BAR BANK) D50=0.35mm
NO. 14 (BANK) D50=0.16mm
NO. 13 (BAR) D50=0.0
NO. 15 (BANK) D50=0.12mm
NO. 12 (BAR) D50=0.18mm
NO. 9 (BAR) D50=SILT (PHOTO 7)
NO. 7 (BAR) D50=0.20mm
NO. 6 (BANK) D50=0.06mm
NO. 5 (BAR) D50=0.13mm
NO. 3 (BANK) D50=SILT
NO. 2 (BAR) D50=0.20mm (PHOTO 2)
WOOD BUFFALO NATIONAL PARK
NORTHWEST TERRITORIES
LAKE ATHABASCA
N

NOTES:

1. SAMPLES COLLECTED FROM EXPOSED BARS OR RIVER BANKS.
2. MEDIAN GRAIN SIZE (D_{50}) GIVEN IN mm.
3. IF D_{50} IS SMALLER THAN 0.06mm, SAMPLE IS REFERRED TO AS SILT.
4. ALL SAMPLES COLLECTED BETWEEN 5 AND 8 JULY, 1980

BED AND BANK MATERIAL SAMPLES ALONG THE SLAVE RIVER

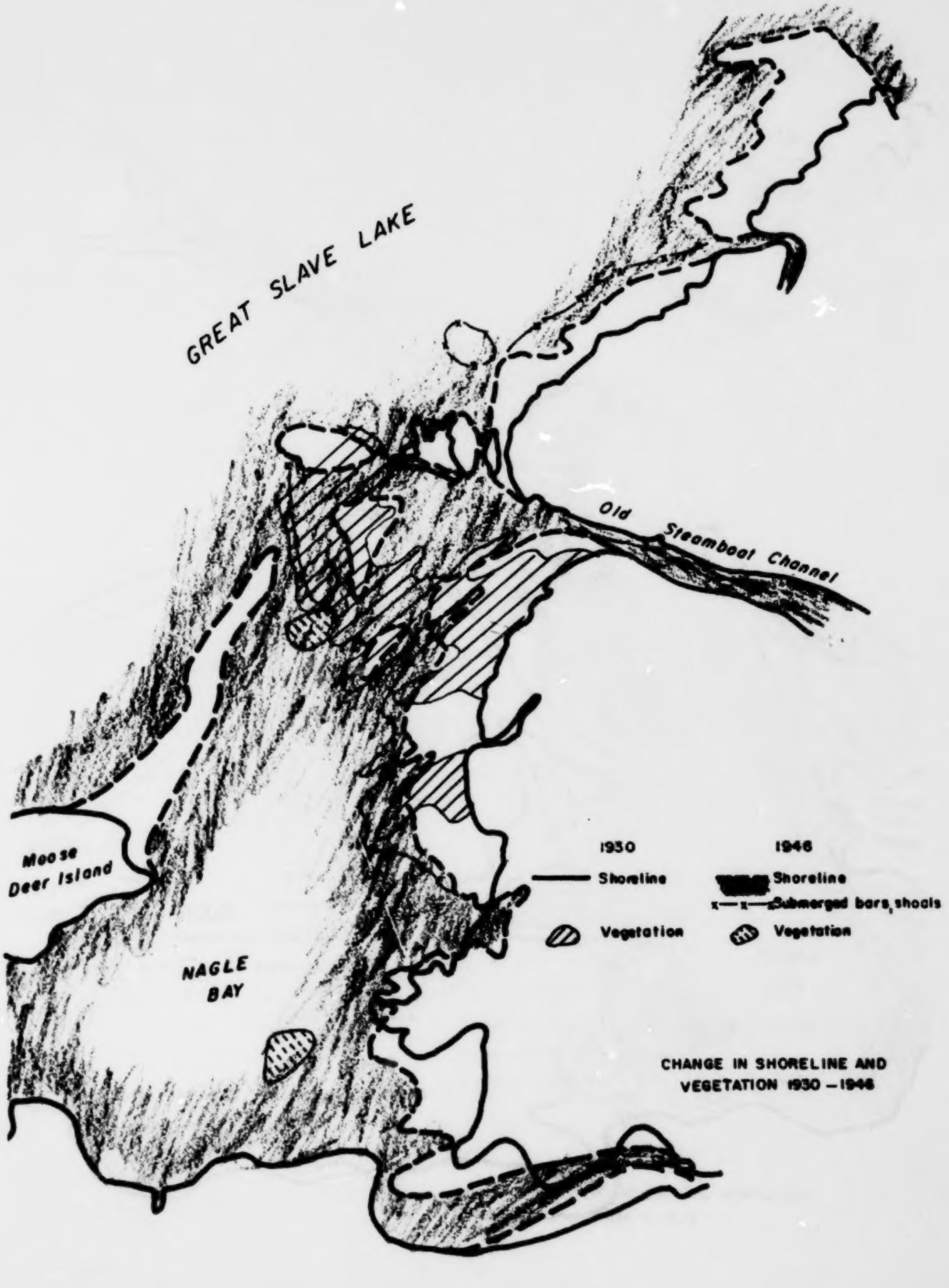
FIGURE 24


POSSIBLE DAM SITES
PEACE, ROCHERS CONFLUENCE
FITZGERALD
FORT SMITH
HEAD OF SLAVE DELTA
GREAT SLAVE LAKE
km 100
km 213
km 240
km528
km538
EL. 206.7m
EL. 201.8m
EL. 166.5m
EL. 156.7m
SHIELD OUTCROPS
SMITH RAPIDS
ALLUVIAL DEPOSITS
4.9m DROP IN 113km
(0.043 m per km)
35.3m DROP IN 27km
(1.3 m/km)
9.8m DROP IN 298km
(0.033 m per km)

NOTE: WATER SURFACE ELEVATIONS OF RIVER APPROXIMATELY CORRESPOND TO THE MEAN ANNUAL DISCHARGE OF 3730 m^3/s, WHILE THE SURFACE ELEVATION OF THE LAKE IS THE MEAN LAKE LEVEL.

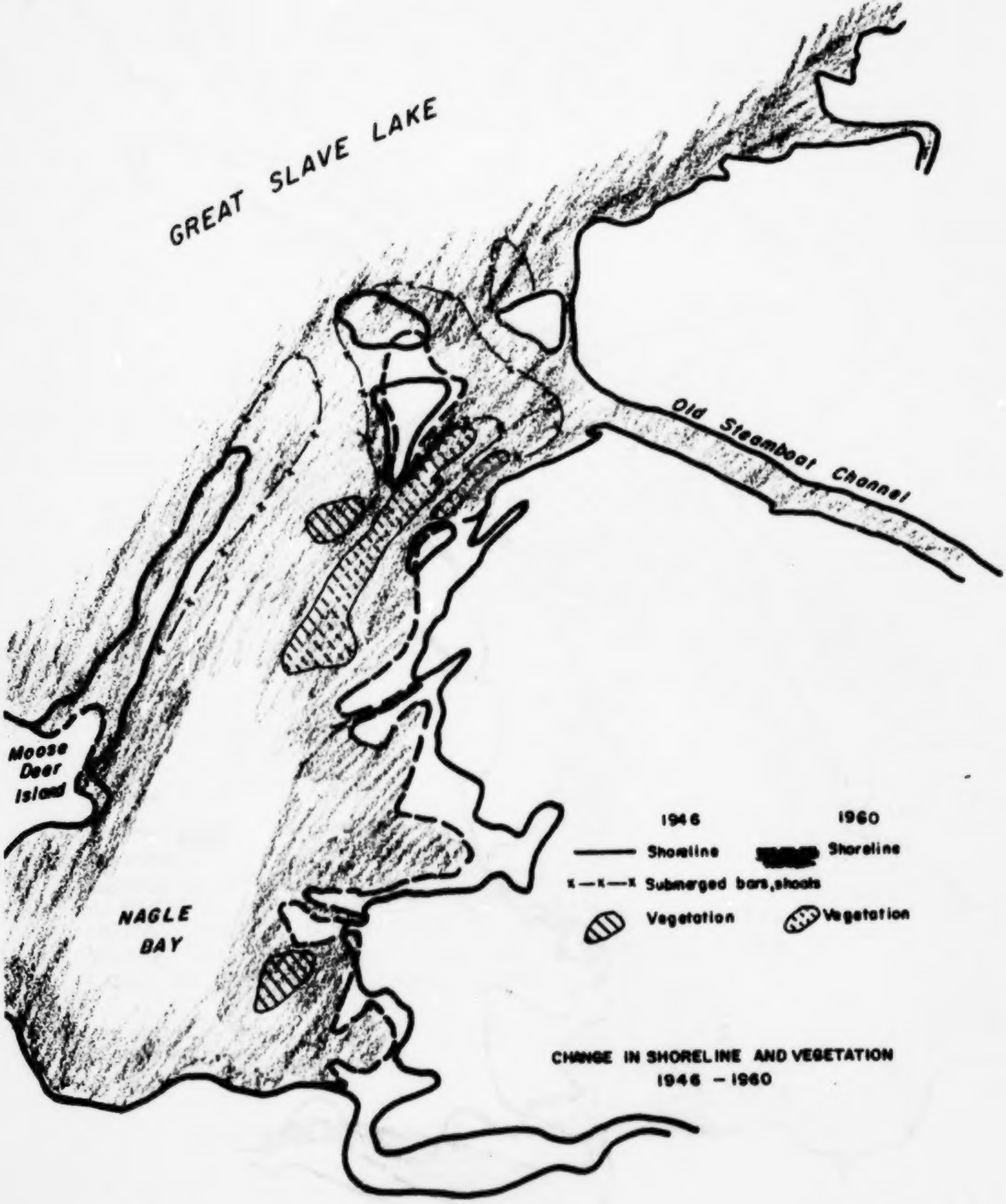
LONGITUDINAL PROFILE OF THE SLAVE RIVER

FIGURE 25


GREAT SLAVE LAKE
Old Steamboat Channel
Moose Deer Island
NAGLE BAY
1930
Shoreline
Vegetation
1946
Shoreline
Submerged bars, shoals
Vegetation

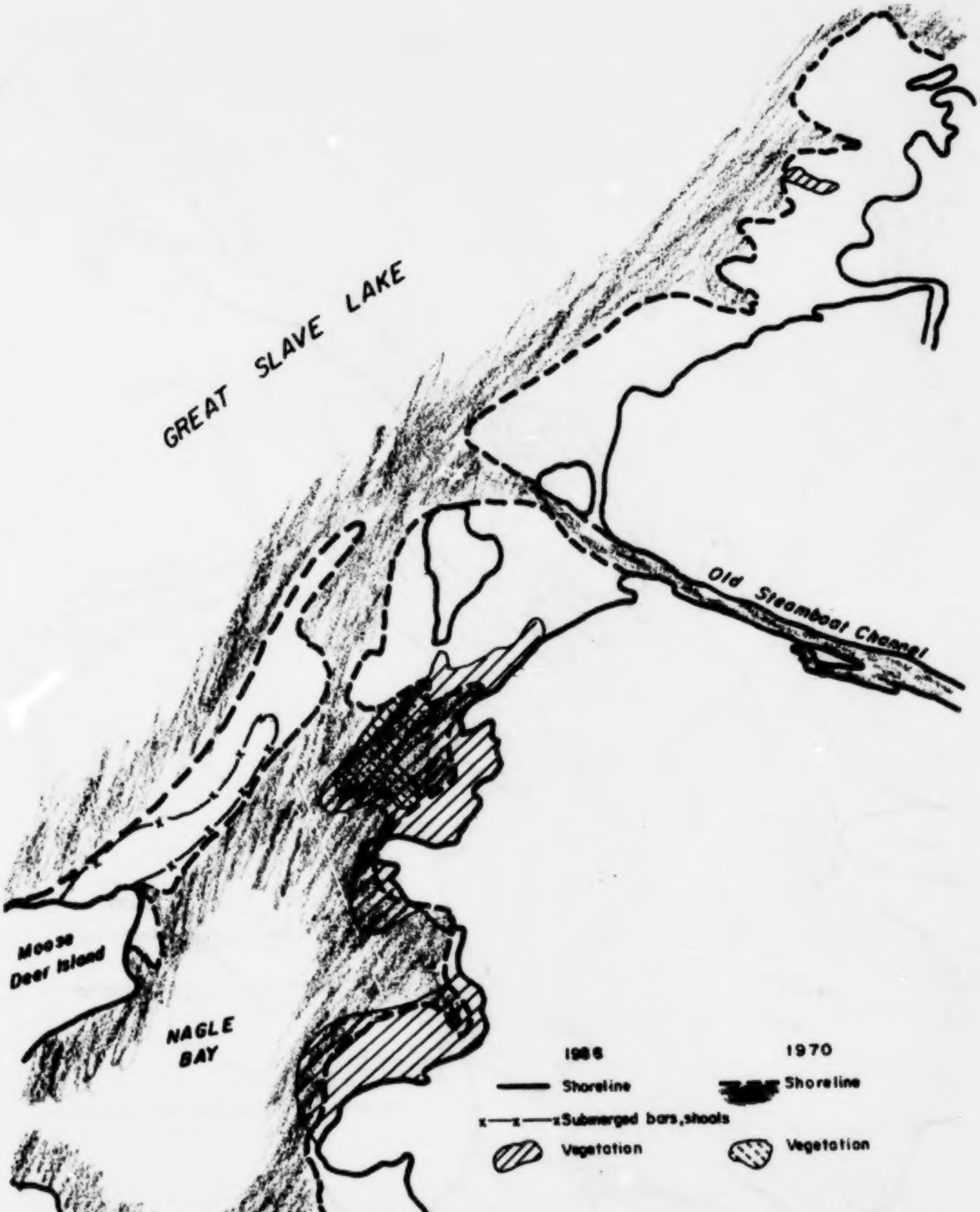
CHANGE IN SHORELINE AND VEGETATION 1930 – 1946

FIGURE 28


GREAT SLAVE LAKE
Old Steamboat Channel
Moose Deer Island
NAGLE BAY
1946
1960
Shoreline
Shoreline
x—x—x Submerged bars, shoals
Vegetation
Vegetation

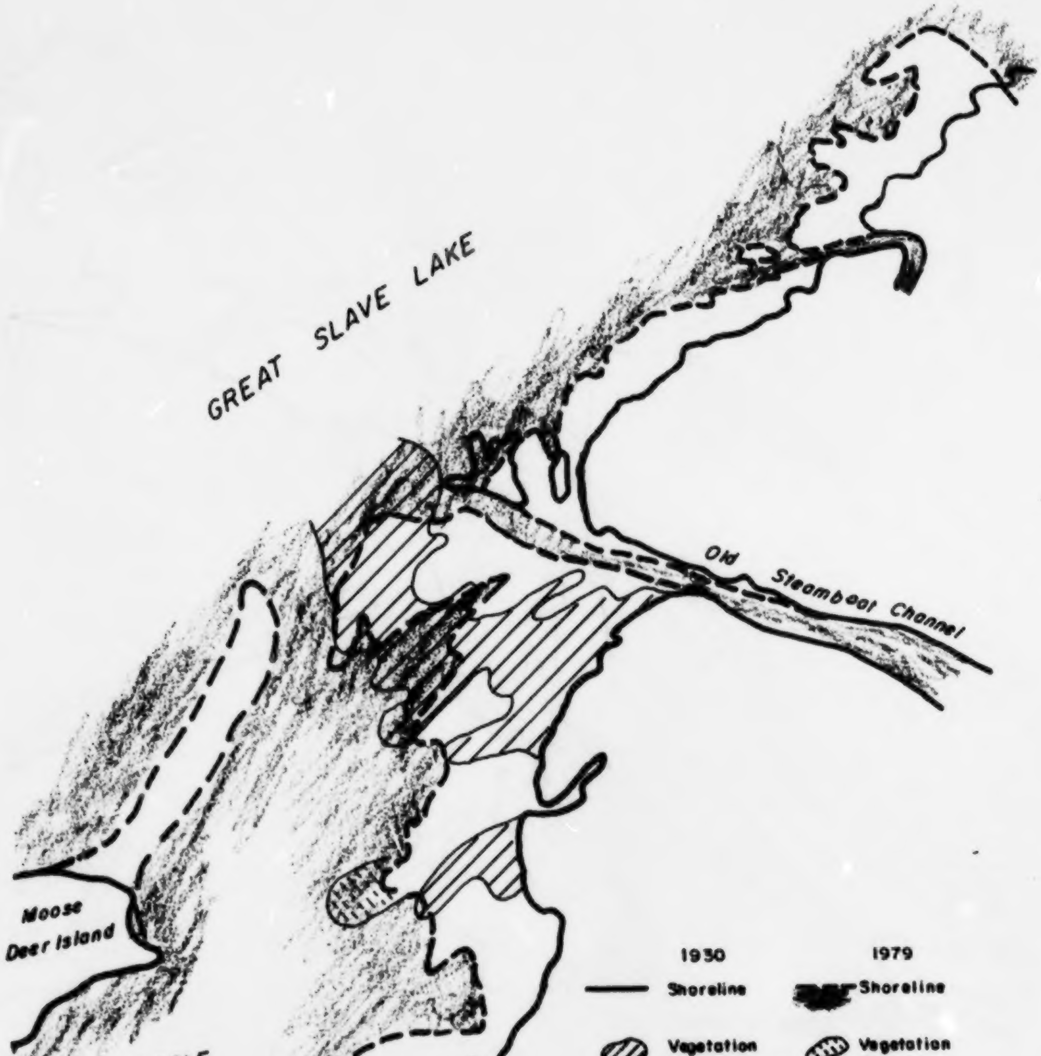
CHANGE IN SHORELINE AND VEGETATION
1946 – 1960

FIGURE 27


GREAT SLAVE LAKE
Old Steamboat Channel
Moose Deer Island
NAGLE BAY
1966
1970
Shoreline
Shoreline
x—x—x Submerged bars, shoals
Vegetation
Vegetation

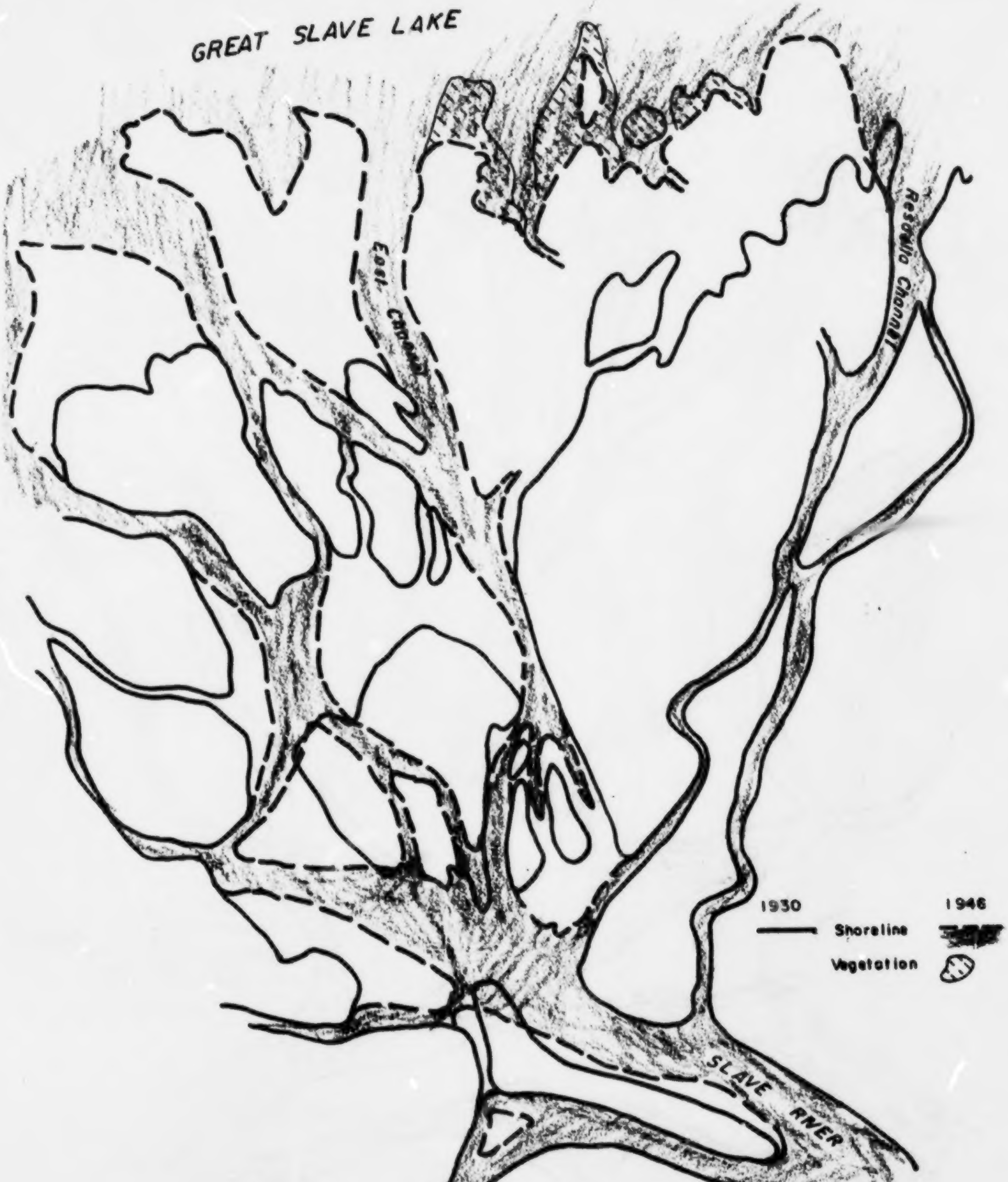
CHANGE IN SHORELINE AND VEGETATION
1966 – 1970

FIGURE 28


GREAT SLAVE LAKE
Old Steamboat Channel
Moose Deer Island
NAGLE BAY
1930
Shoreline
Vegetation
1979
Shoreline
Vegetation

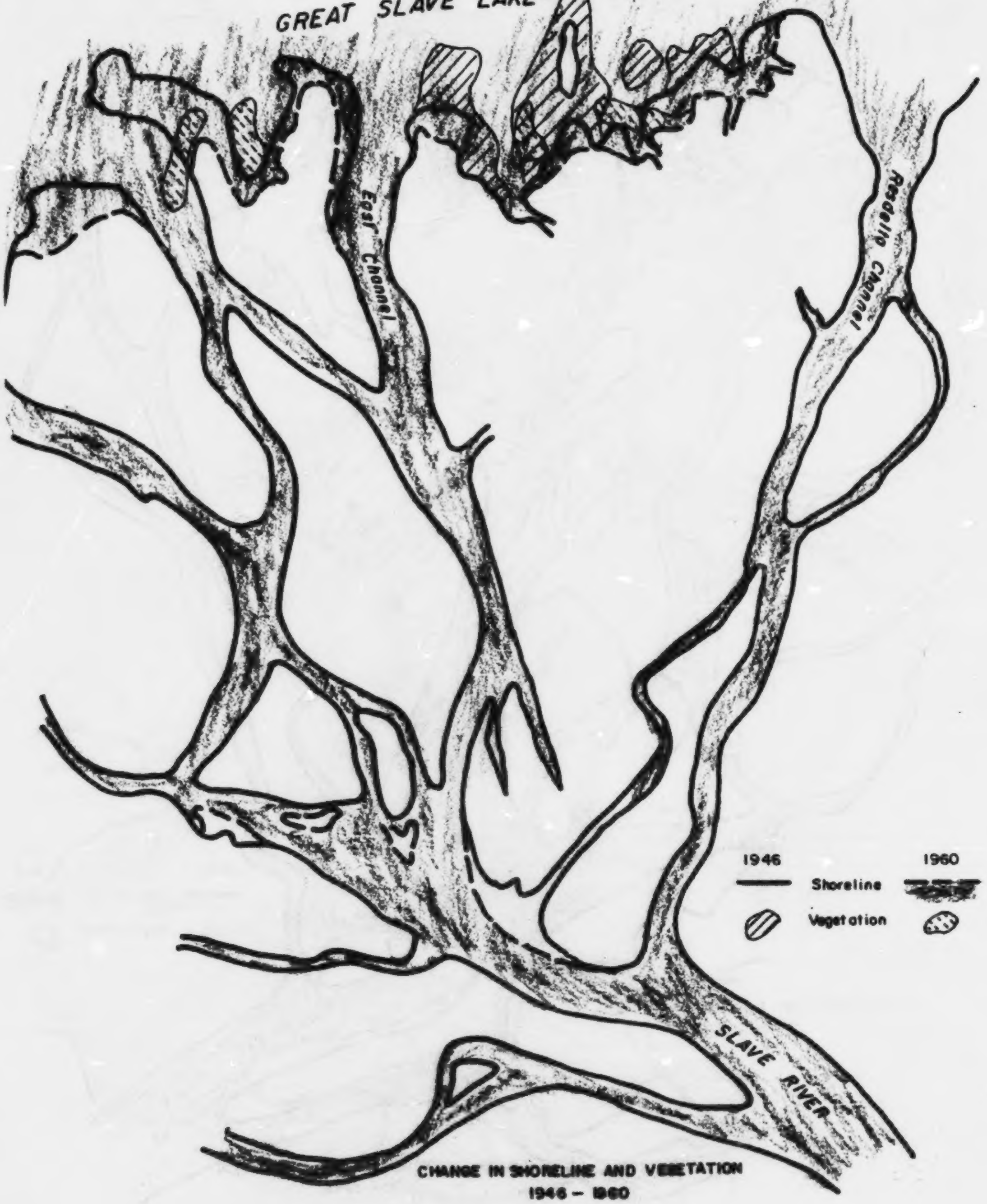
CHANGE IN SHORELINE AND VEGETATION
1930 – 1979

FIGURE 29


GREAT SLAVE LAKE
East Channel
Resdello Channel
SLAVE RIVER
1930
1946
Shoreline
Vegetation

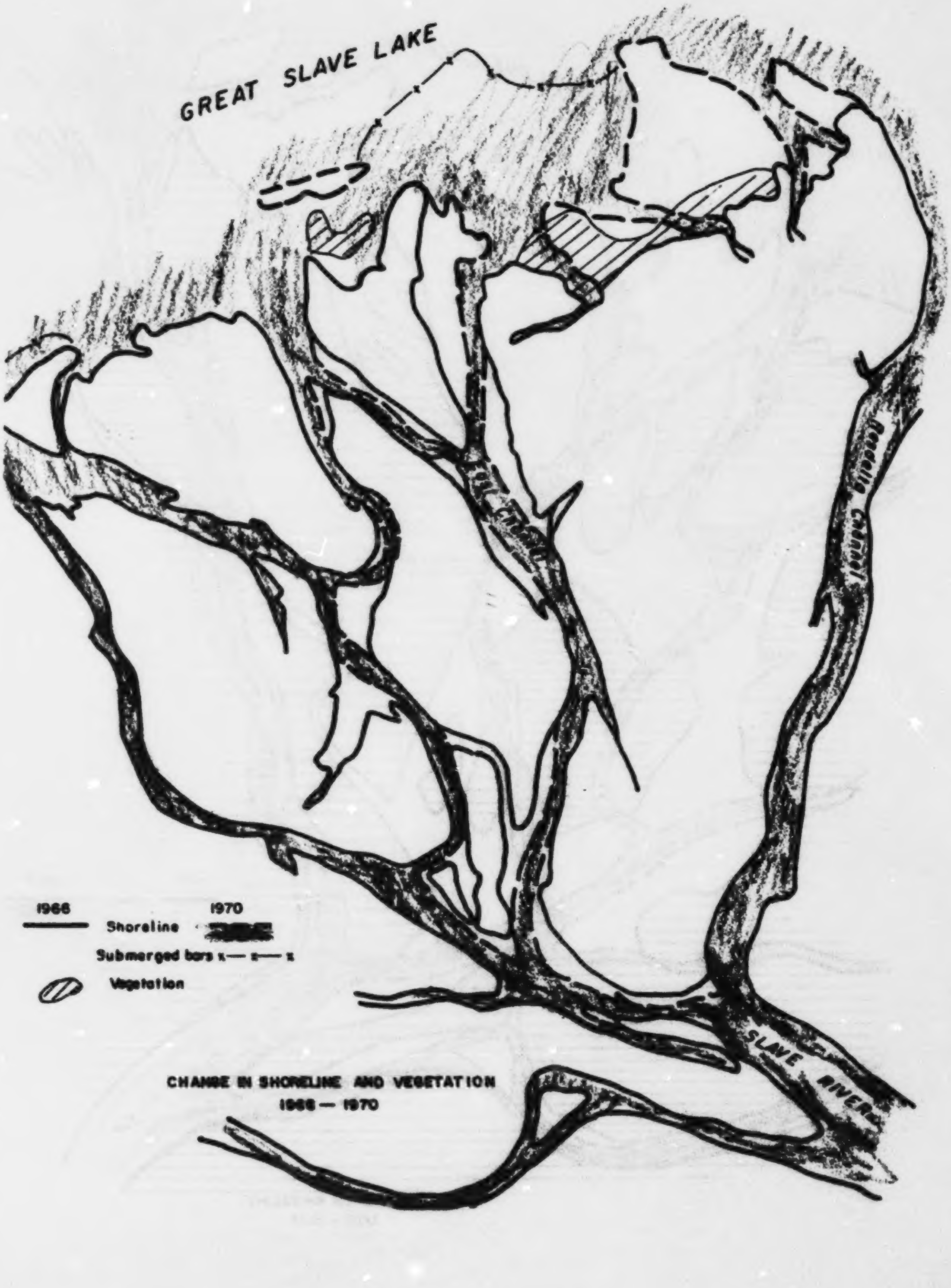
CHANGE IN SHORELINE AND VEGETATION
1930 – 1946

FIGURE 30


GREAT SLAVE LAKE
East Channel
Resdelta Channel
SLAVE RIVER
1946
1960
Shoreline
Vegetation

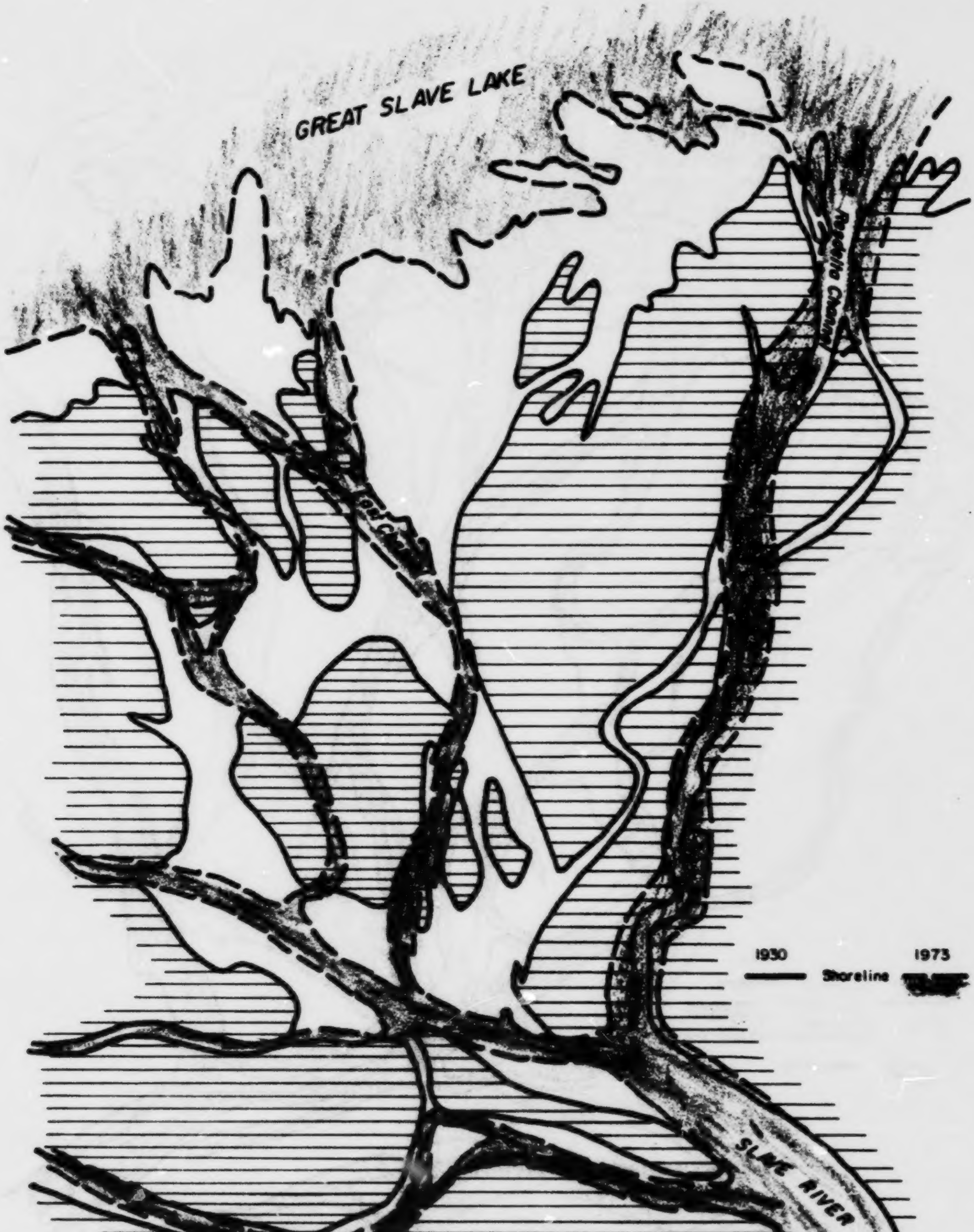
CHANGE IN SHORELINE AND VEGETATION
1946 - 1960

FIGURE 31

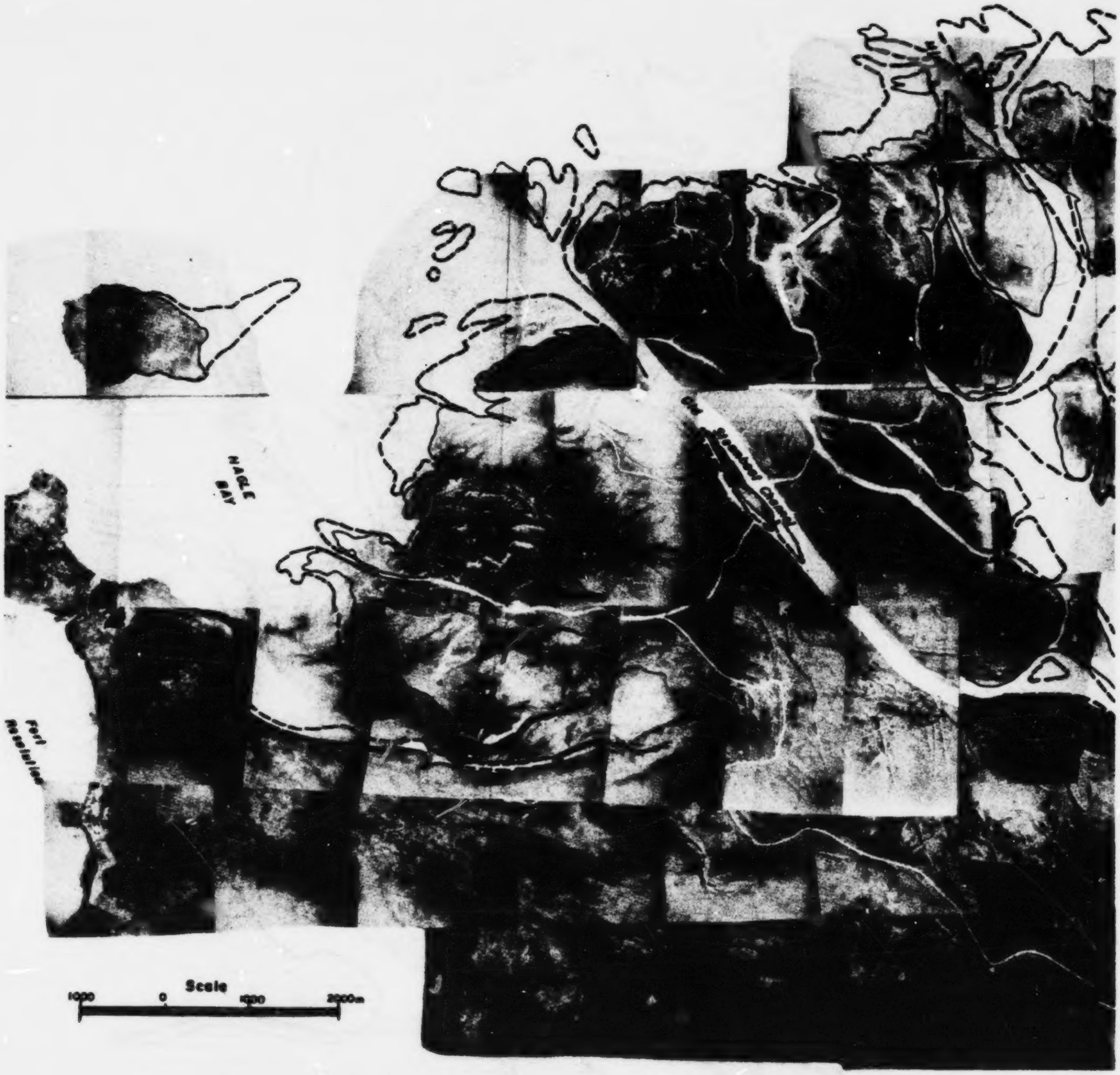

GREAT SLAVE LAKE
Channel
Resdelta Channel
SLAVE RIVER
1966
1970
Shoreline
Submerged bars x— x— x
Vegetation

CHANGE IN SHORELINE AND VEGETATION
1966 — 1970

FIGURE 32


GREAT SLAVE LAKE
Resdelta Channel
Old Chan
SLAVE RIVER
1930
1973
Shoreline

CHANGE IN SHORELINE
1930 - 1973



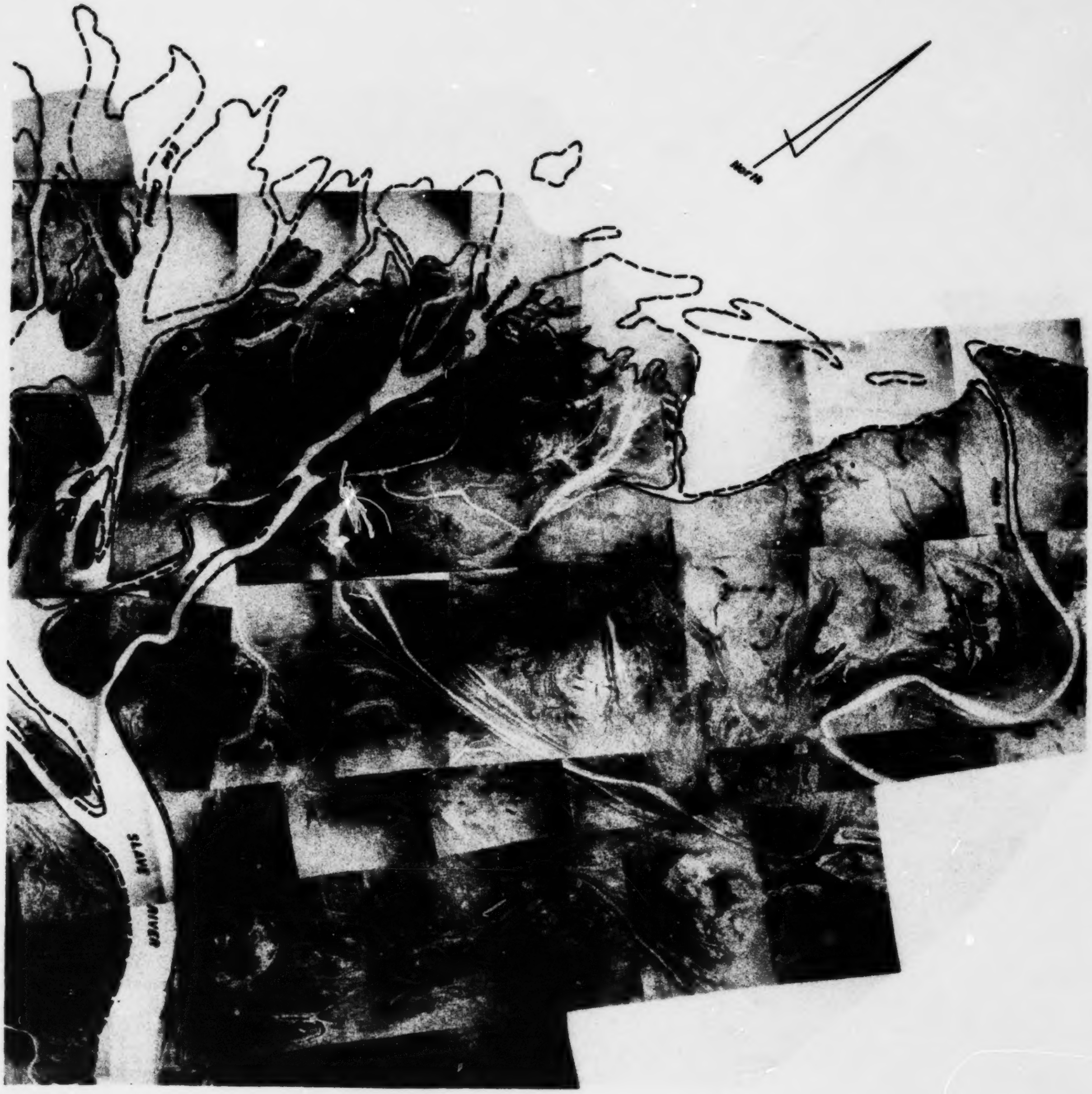
NAGLE BAY
Old Steamboat Channel
Fort Resolution
Scale
1000
0
1000
2000m

Slave Delta Change
1930 - 1946

LEGEND

——— Shoreline August 21,1930
– – – – Shoreline advance July 11,1946

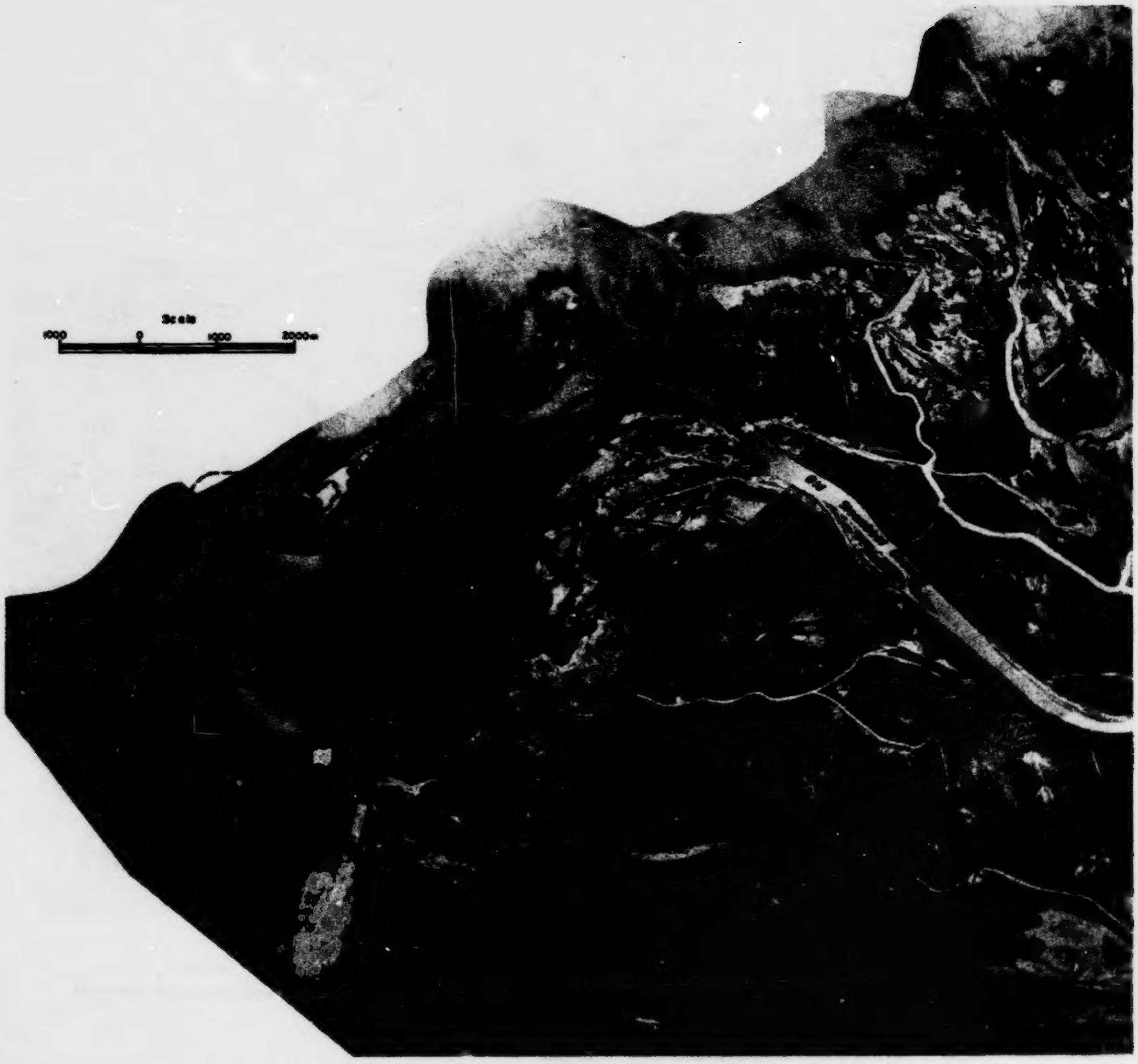
FIGURE 34



From 1930 - 1946 the delta advanced about 0.5 km, and the Resdelta Channel enlarged at the expense of the East and Middle Channels (shown on 1930 photomosaic).

Prepared by:
J. D. Mollard and Associates Limited
January 30, 1981

FIGURE 34 (CONT'D)

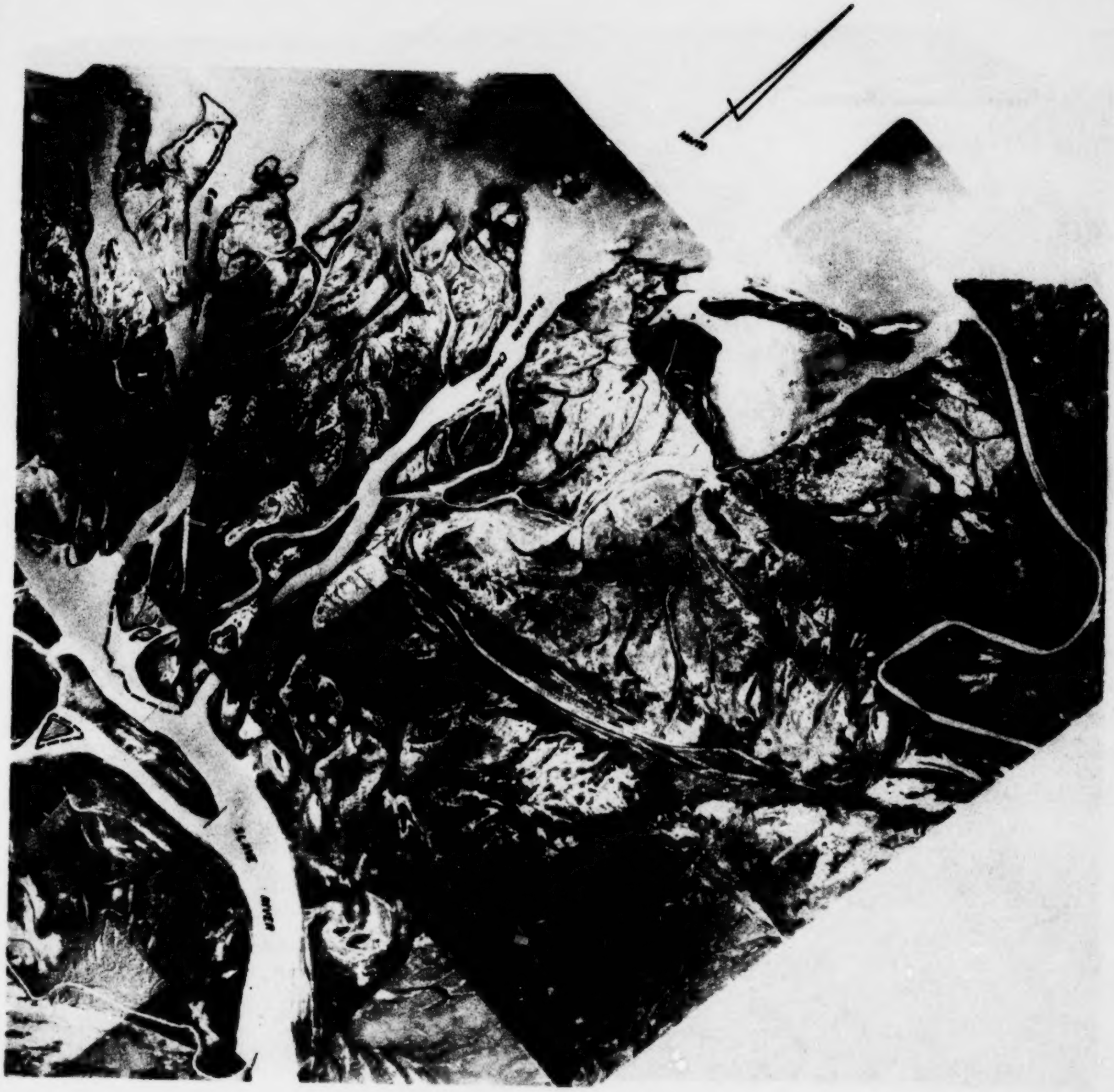

Scale
1000
0
1000
2000m

Slave Delta Change
1946 - 1960

LEGEND

——— Shoreline July 11,1946
– – – – Shoreline advance July 21,1960

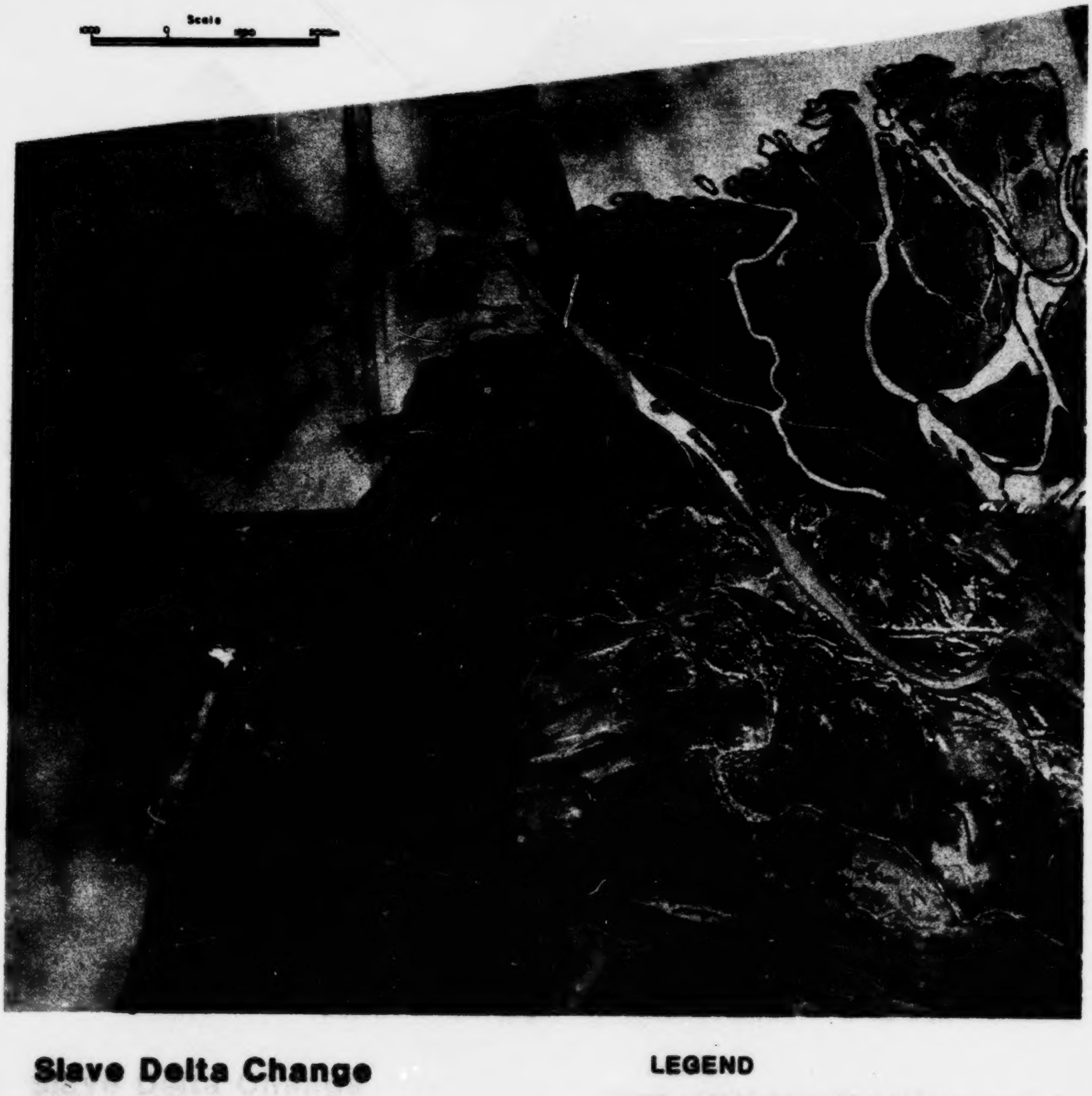
FIGURE 35



The shoreline changed little from 1946 - 1960, but the Resdelta Channel continued to enlarge at the expense of the Middle Channel (shown on 1946 photomosaic).

Prepared by:
J. D. Mollard and Associates Limited
January 30, 1981

FIGURE 35 (CONT'D)


Scale
1000
0
1000
2000m

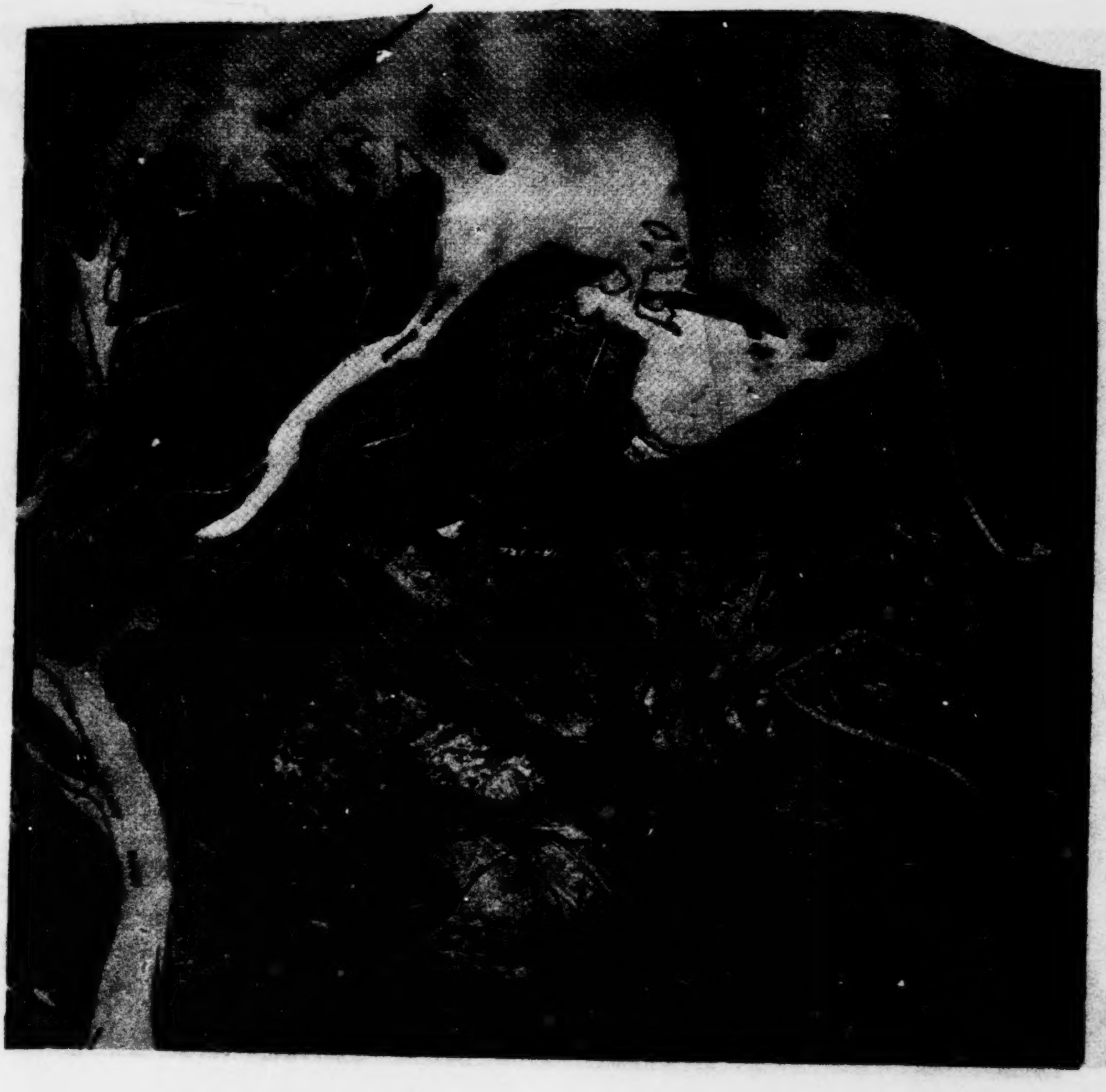
Slave Delta Change
1960 - 1973

LEGEND

——— **Shoreline July 21,1960**

- - - - **Shoreline advance July 10,1973**

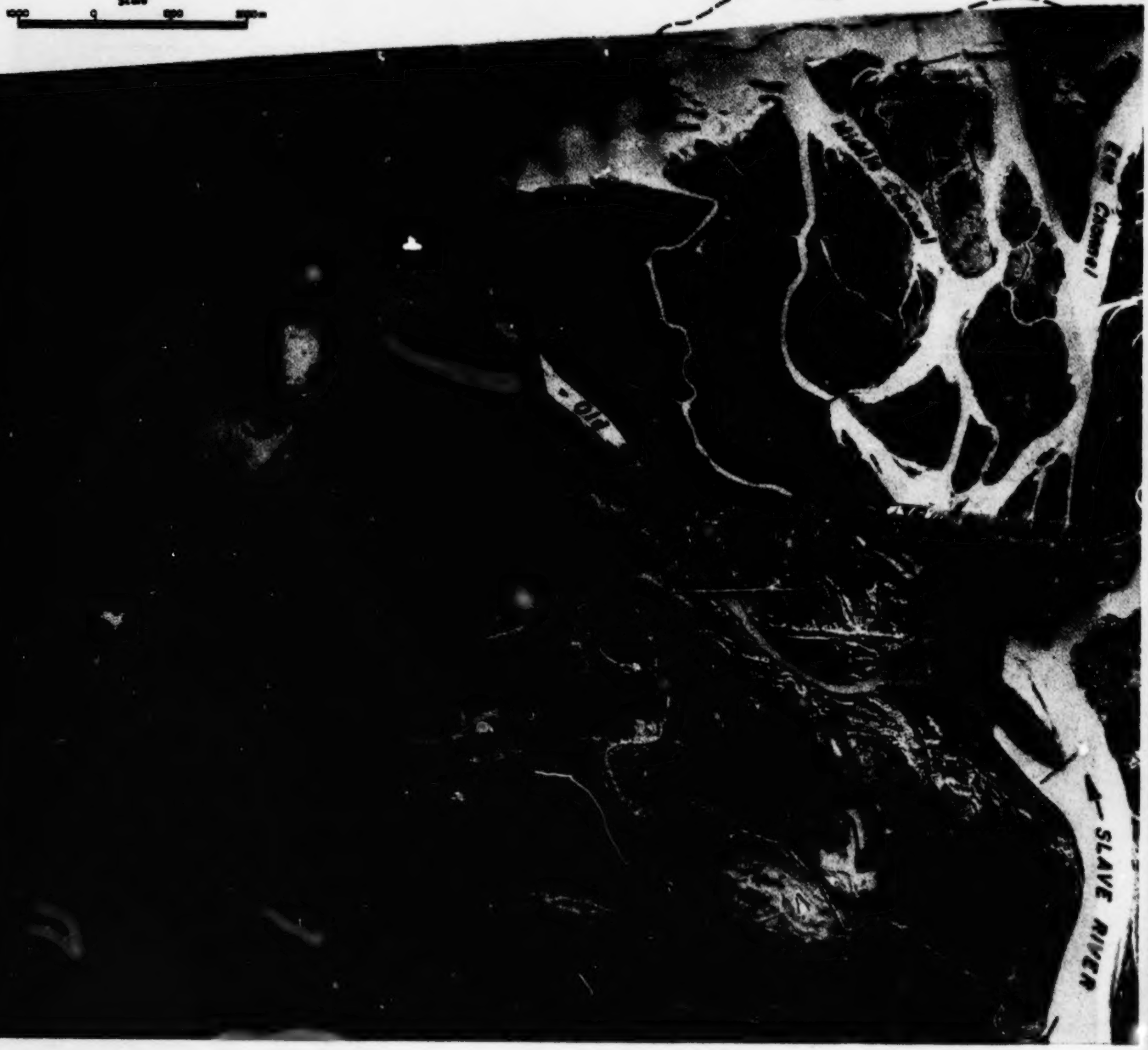
FIGURE 36



The shoreline changed little from 1960 - 1973, but the Resdelta Channel continued to enlarge at the expense of the East and Middle Channels (shown on 1960 photomosaic).

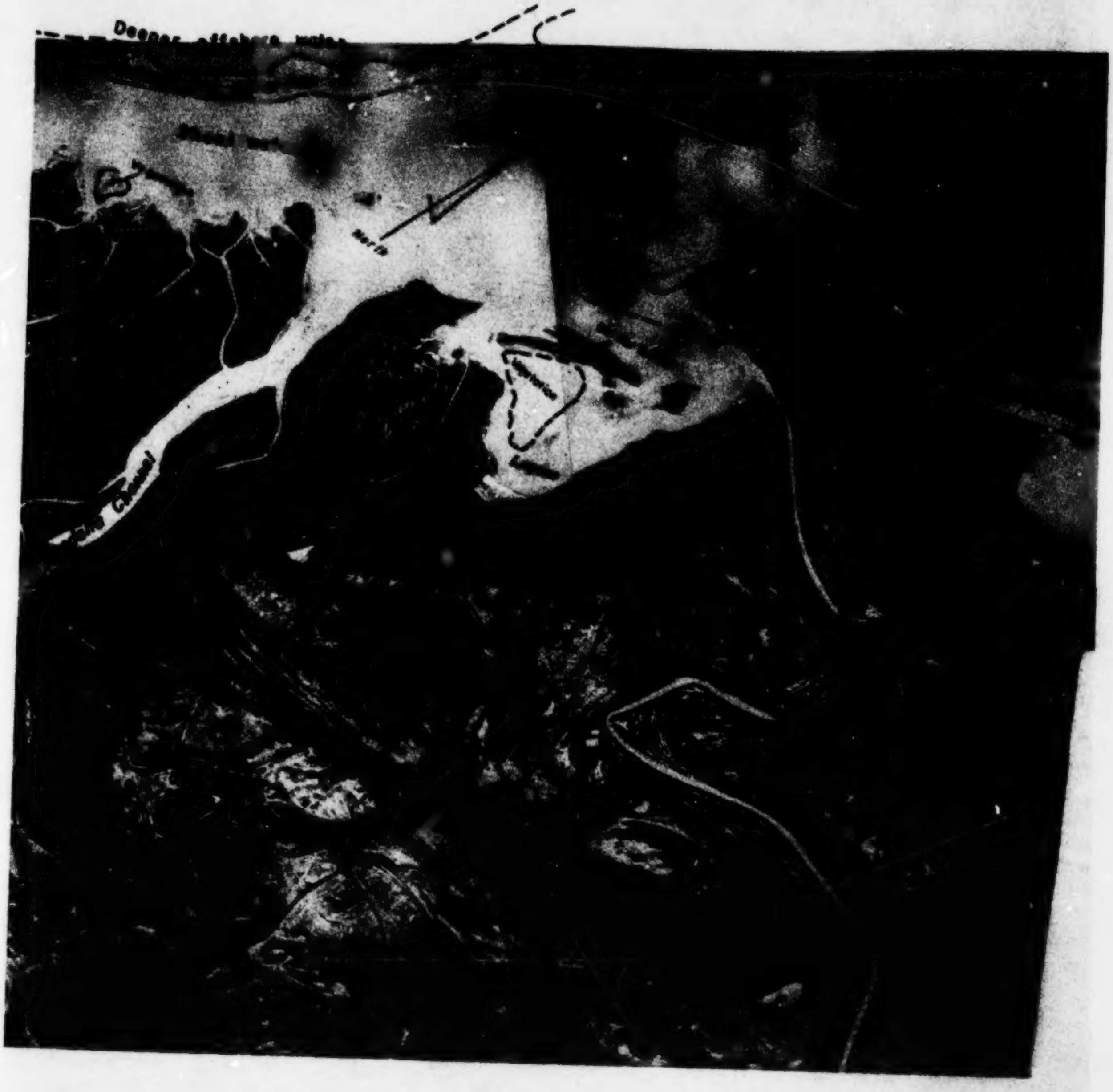
Prepared by:
J. D. Mollard and Associates Limited
January 30, 1981

FIGURE 38 (CONT'D)


Scale
0
Channel
SLAVE RIVER

Submerged Outer Bar
and Line of Breakers

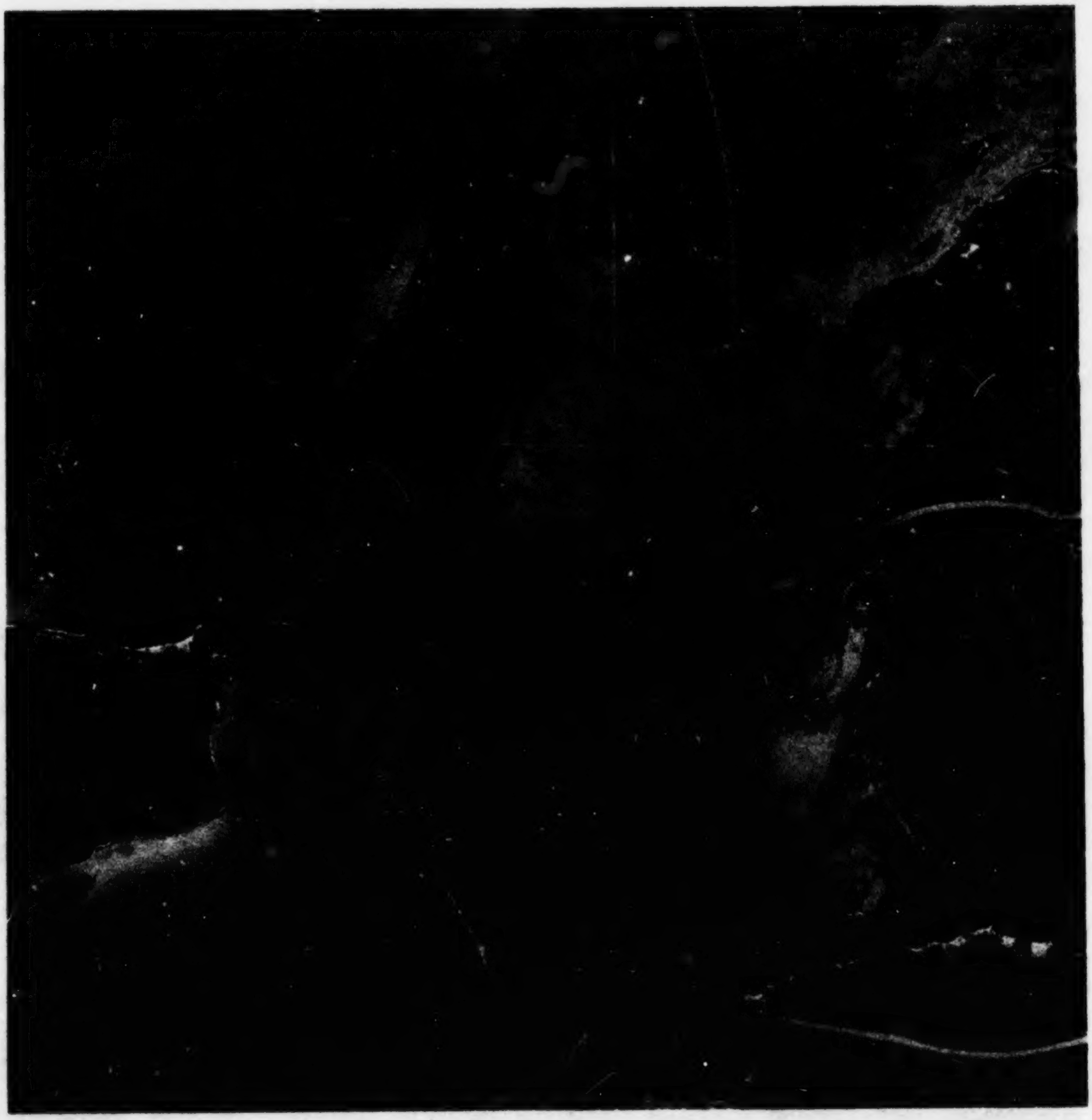
FIGURE 37


Deeper offshore water
North
Channel

This July 1960 photomosaic shows the position of submerged outer bar and line of breakers (surf, whitecaps). Also note patches of inshore emergent vegetation (probably SCIRPUS spp, as SCIRPUS ACUTUS or SCIRPUS VALIDUS).

Prepared by:
J. D. Mollard and Associates Limited
January 30, 1981

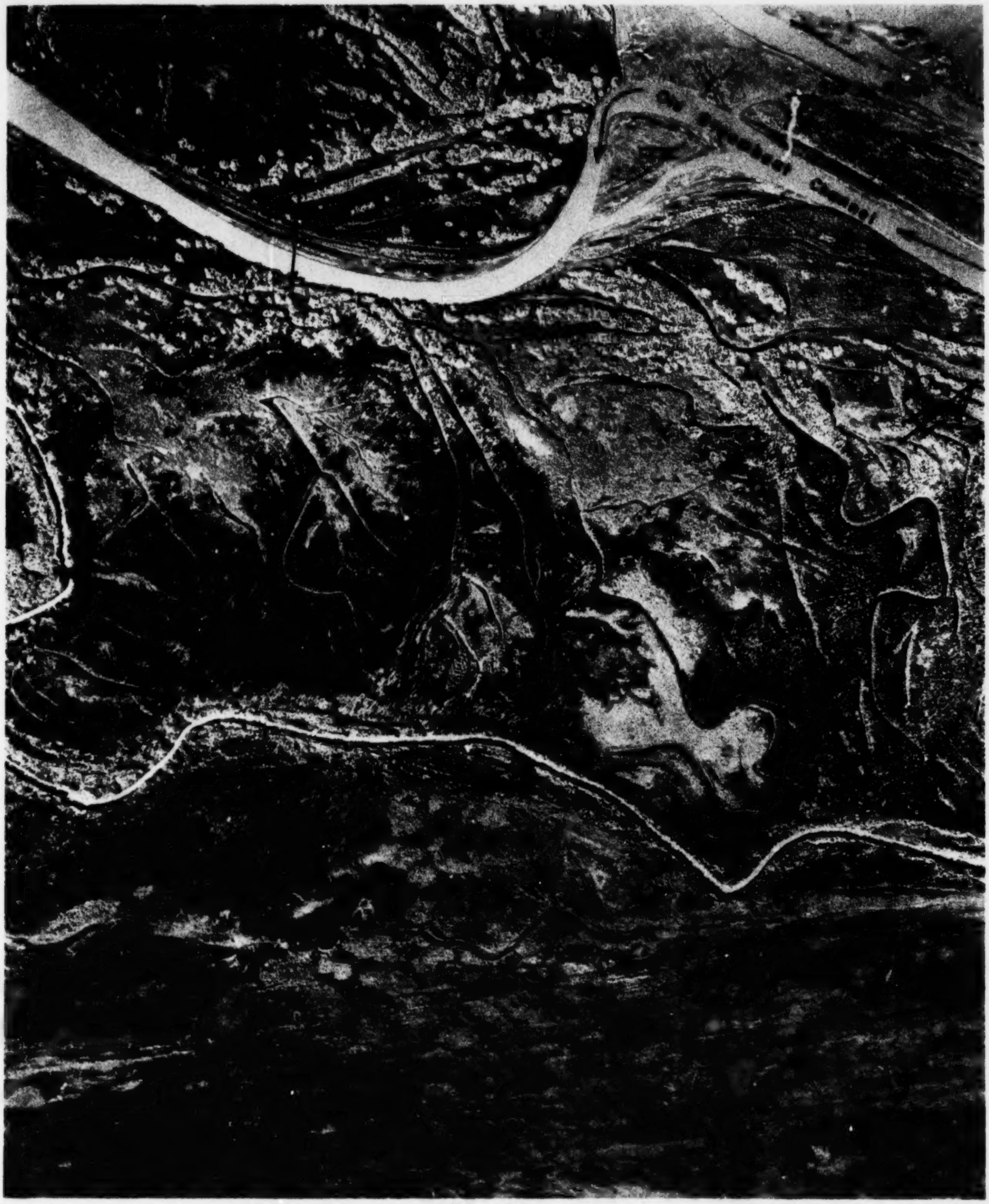
FIGURE 37 (CONT'D)



ACTIVE DELTA DEPOSITION AND NEARSHORE VEGETATION (PROBABLY HARDSTEM BULRUSH (SCIRPUS ACUTUS). SEPTEMBER, 1966

Scale 1:24,000

FIGURE 38


Old Steamboat Channel

BALSAM POPLAR AND WHITE SPRUCE ALONG NAGLE CHANNEL, SLAVE RIVER DELTA, SEPTEMBER, 1966

Scale 1 : 24,000

FIGURE 39

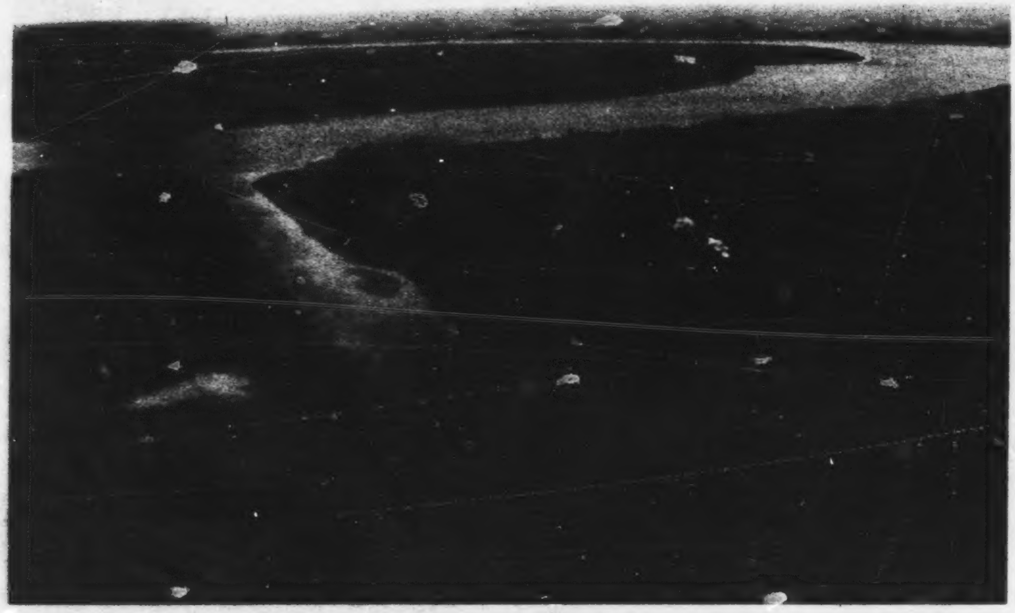


Photo Km 497. Outlet of Ring Lake, an ancient meander loop of the Slave River. The outlet channel of the lake is shallow and water from the Slave is not entering the lake. (24 July 1980) 403-18-29.

FIGURE 40

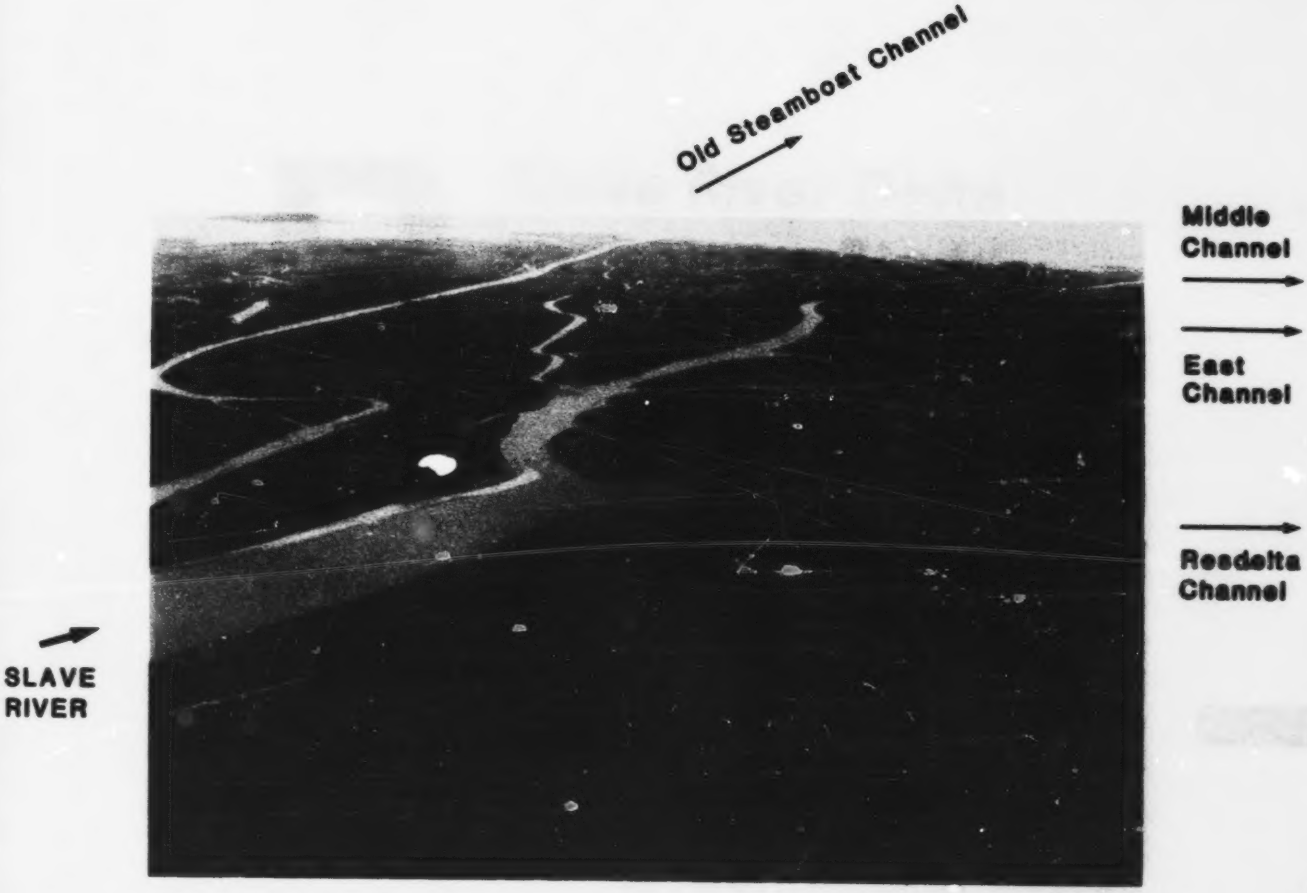

Old Steamboat Channel
Middle Channel
East Channel
Resdelta Channel
SLAVE RIVER

Photo Km 528. Head of the Slave Delta with Great Slave Lake in the background. The bar at the entrance to the Middle and East Channels probably signifies that these channels are losing flow to the Resdelta Channel which presently conveys most of the flow. (24 July 1980) 403-19-9.

FIGURE 41

Photo Km 538. Slave Delta from the south where it enters the lake. Note the bars in the lake which mark the limit of the Delta. These bars are probably formed from Slave River sediments that have been halted by littoral action. (24 July 1980) 403-19-5.

FIGURE 42

DEPARTMENT OF INDIAN AFFAIRS
AND NORTHERN DEVELOPMENT

Northern Affairs Program, Water Resources Division
Yellowknife

B

Slave River Delta Hydrology Study

Prepared by

K.F. Davies

Environment of Canada
Water Survey of Canada
Calgary District Office

Calgary, Alberta

March, 1981

EXECUTIVE SUMMARY

This report highlights streamflow, water level, suspended sediment and water quality data collected in the Slave River Delta during the period June, 1978 to September, 1980, by the Water Survey of Canada. The data is available on request from the Inland Waters Directorate, Environment Canada, Yellowknife, N.W.T.

In the summer months, 86% of the Slave River flows through the Resdelta Channel, 5% through the Middle Channel West, and 9% through the remaining five channels. During winter these percentages change to 93%, 5% and 2%, respectively. Flows in some of the smaller channels during the winter months were close to zero. Water levels fluctuate up to three metres from low fall conditions to high spring peaks during breakup periods. Two distinctly different spring breakups were observed during the study period. The 1979 breakup was a late breakup, with high water levels and subsequent flooding of most of the delta complex. The 1980 breakup was relatively early, with low flows and minimal flooding of the delta lowlands.

Suspended sediment concentration measured at Fort Smith were found to be representative of sediment entering the delta. Concentrations averaged 250 mg/L for the year and rose to 1000 - 2000 my/L in the spring, with the highest suspended sediment load of 6900 t occurring in June 1979.

A limited baseline water quality sampling program was undertaken just above the delta. The long-term data at Fort Smith were found to be representative of the short-term delta measurements, for the parameters used in the analysis. It was found the Slave River contains moderate amounts of dissolved solids with typical values ranging from 100 to 140 mg/L. Most metals are present at undetectable or very low concentrations with the exception of iron and manganese. Herbicides, picoloram, and most cholorinated hydrocarbons have never been detected in the waters of the Slave River.

The study period encompassed only two spring breakups and a limited range of flow values and therefore does not permit a proper assessment of the interactions within the delta. It is recommended that the spring breakup observations and some of the flow distribution studies be continued for another five years, or until a wider range of flows are experienced.

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CHAPTER I

INTRODUCTION AND METHODOLOGY

Main objectives of the study were to determine, for the first time, distribution of streamflow within the Slave River Delta and the water level fluctuations in the main channels and some of the smaller distributory channels. Also unknown at the time of the study, and which the study partially addressed in terms of data collection, was the extent to which water levels fluctuate within the delta channels as a result of spring runoff, high summer flows, and wind effect from Great Slave Lake, Suspended sediment loads and baseline water quality conditions within the delta were also addressed; however, results were limited due to the remote locality of the hydrometric gauging stations which limited data collection to only the period when data collection trips were made to the sites by Water Survey personnel.

A. Geodetic Survey of Canada Elevations

At the nine hydrometric stations selected (Figure 1) stable bench marks were established and tied to a common datum by a 37 km long closed level circuit. The first level circuit of March 1978 was rerun in March 1979 to verify the stability of the bench mark network. An additional closed circuit was run to Fort Resolution to tie the delta network to Geodetic Survey of Canada elevations; however, because this work was not done by Geodetic Survey personnel, the derived elevations are 'approximate' although they are of similar accuracy.

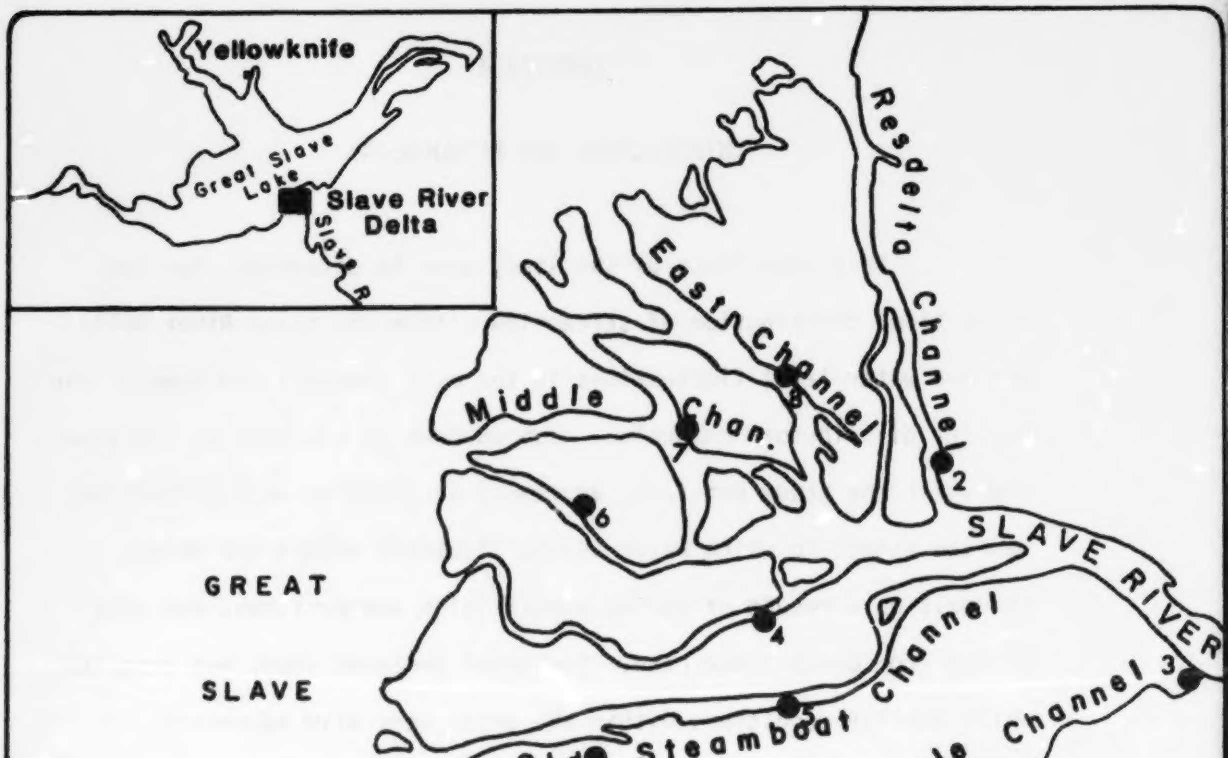
Yellowknife
Great Slave Lake
Slave River Delta
Slave R.
Resdelta Channel
East Channel
Middle Chan.
SLAVE RIVER
GREAT SLAVE LAKE
Channel
Old Steamboat
Nagle Channel
Sawmill Channel
Moose Deer Island
Fort Resolution
1
2
3
4
5
6
7
8
Gauging Station Locations in the Slave River Delta
SCALE
3 2 1 0 3 km.

Figure 1.

B. Establishment of Hydrometric Stations

Hydrometric stations are basically the locations, carefully selected on their basis to accurately monitor water levels and determine streamflow discharge volumes, and they may or may not involve equipment installations to ascertain either water levels or streamflows. Water levels were initially recorded by seven strip chart automatic water level recorders at main flow sites, and two manual gauges were installed at two lesser flow sites (Figure 1). One of these two lesser sites was later identified as having an appreciable amount of flow and was equipped with an automatic water level recorder prior to the 1979 open water season. Streamflow discharge measurements were made from a boat at the nine hydrometric stations and therefore the installation of site specific streamflow measuring equipment was not required.

C. Water Level and Streamflow Measurements

The eight automatic water level recorders operated satisfactorily with a minimum of record loss. This high degree of water level recovery was achieved through the installation of hydrometric recorders at sites which would encounter a minimum amount of problems caused by high flows and monthly or more frequent visits to the sites to ensure the equipment was properly functioning or making required repairs to minimize record loss. This continuous record provided a good base for converting the water level to daily streamflows by means of discharge measurements relating streamflow to water levels.

Flow measurements were made on a monthly basis at all hydrometric stations. Measurements were made by determining the velocity, depth and width at twenty to twenty-five locations across the stream, which were selected on the basis that each flow panel consisted of approximately five per cent of the total flow. Velocities were determined from current meter observations at either 0.2 and 0.8 points of the depth, or at the 0.6 point of the depth. Depths were ascertained by utilizing a standard sounding weight lowered by a reel equipped with a counter. Widths were determined by either stringing a distance marked tagline across the stream or utilizing an electronic distance measuring device.

D. Sediment Measurements

A short trial period of measuring suspended sediment concentrations at hydrometric stations within the delta and comparing these with sediment measurements taken at Fort Smith showed them to be comparable. The latter existing station at Fort Smith provided, at much lower cost, a reasonable approximation of sediment flowing into the Slave River Delta.

Measurements were made by the depth-integrated sediment discharge method. This method, recognizing that the concentration of sediment sediments varies across the stream, requires that the stream cross-section be divided into at least five equal flow panels. At each of these panels the sediment sampler was lowered and raised through the total depth at a constant rate to obtain a representative sample for each panel.

CHAPTER II

RESULTS

The following is a summary only. The water level, streamflow and sediment data is available on request from Chief, NWT Programs, Inland Waters Directorate, Box 2970, Yellowknife, NWT and water quality data is available on request from Resources Officer, Water Quality Branch, Bag 2909, Postal Station 'M', Calgary Alberta. The data is not included in this report as it is of a large volume and the daily records produced are of use for specific studies, whereas the evaluation conducted in this report only considers the general aspects of the data obtained during the study.

A. Water Level

Water level data were monitored in the delta during three summer periods, two spring breakups, and two winter periods. A range of flow from a low of 1 800 cubic metres per second to a high of 7 000 cubic metres per second encompassed the average range of discharge encountered since the Slave River has been partially controlled in its headwaters by Bennett Dam located on the Peace River.

The main source of water replenishment to the delta wetlands and lowlands is the spring breakup period. Flooding of the delta by summer storm events in the headwaters of the Slave River was not encountered during the study.

During the 1979 spring breakup, major ice jams occurred on May 22 and 23, which caused flooding in most of the delta, refilling potholes and small sloughs. Maximum instantaneous water levels recorded during this period were.

Hydrometric Station	Day and Time (1979)	Water Level (metres above mean sea level)
Jean River	May 21 @ 22:00 MST	158.789
Nagle Channel	May 22 @ 01:00 MST	158.388
Resdelta Channel	May 22 @ 04:00 MST	158.159
East Channel	May 22 @ 11:00 MST	158.040
Middle Channel East	May 22 @ 12:00 MST	157.722
Middle Channel West	May 22 @ 18:00 MST	158.282
West Channel	May 22 @ 18:00 MST	158.282
Old Steamboat Channel	May 23 @ 02:00 MST	158.197
West Channel off Old Steamboat Channel	May 23 @ 12:00 MST	157.596

Great Slave Lake water levels during the same period were 156.75 metres above mean sea level. As the water levels of the channels and the lake would have been relatively similar prior to breakup, it can be seen that breakup can increase the water level in the delta by at least two metres.

The 1980 spring breakup occurred during the period April 30 to May 2, with maximum water levels from 0.5 to 1.0 metres lower than in 1979. Consequently, there was minimal flooding of the delta lowlands.

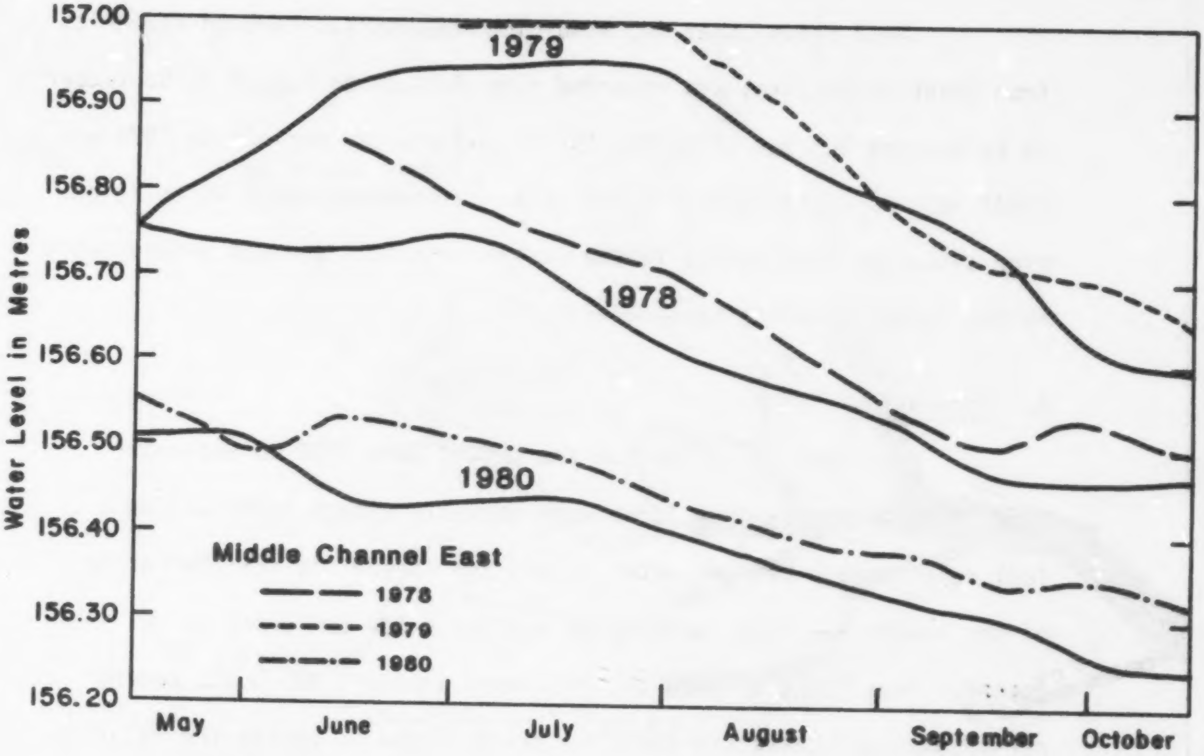

Figure 2: Great Slave Lake at Fort Resolution and Middle Channel East Water Levels

The comparison of Great Slave Lake at Fort Resolution to Middle Channel East water levels (Figure 2) indicates that a relationship exists between water levels in the lake and Slave River delta channels. Great Slave Lake at Fort Resolution is a permanent water level station and therefore based on the relationship established during the study period, it is possible to determine the water level in the Slave delta channels during other years.

Wind setup; that is, wind blowing upstream through the delta from Great Slave Lake, was recorded from July 28 to August 1, September 15 to 20, and October 15 to 17, 1978 (and similar periods in 1979 and 1980) raising water levels in the delta channels by about 10 to 20 cm. Wind setup was felt mainly in the smaller channels and was undetectable in the larger Resdelta Channel.

B. Streamflow

Data was collected for the period June 1978 to September 1980. The only year that flows were variable enough to establish a full relationship between water levels and streamflow for the period of the study, was 1979, when flows reached 7 000 cubic metres per second. Peak flows in 1978 and 1980 were around 5 000 cubic metres per second, and therefore could not be utilized to verify the relationship established above this flow in 1979. Data collected during the three open water seasons were utilized to accurately prepare the water level to streamflow relationships (stage discharge curves) for all of the hydrometric stations in the delta for total Slave River flow of less than 5 000 cubic metres per second and above this flow the relationship was dependent upon 1979 streamflow measurements.

The percentage distribution of Slave River flow in the main channels on a monthly basis for the study period (Table 1) is also shown in Figure 3. The Resdelta Channel carries 88% of the flow during the open water periods and up to 93% during the winter periods. The channel referred to as Middle Channel West conveys about 5% of the flow throughout the year. The remaining flow, 7% in the open

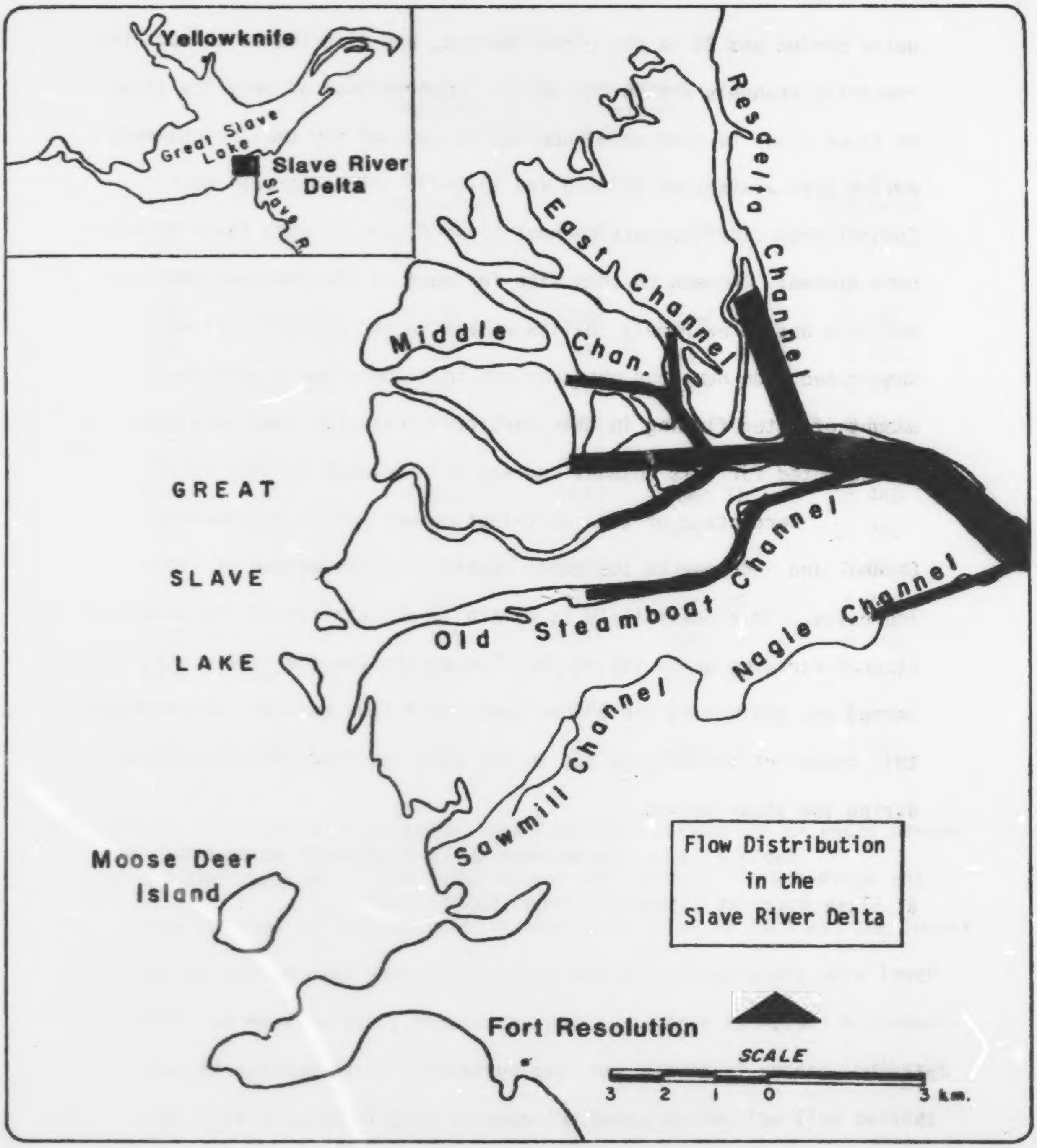
Yellowknife
Great Slave Lake
Slave River Delta
Slave R.
Resdelta Channel
East Channel
Middle Chan.
GREAT SLAVE LAKE
Old Steamboat Channel
Nagle Channel
Sawmill Channel
Moose Deer Island
Flow Distribution in the Slave River Delta
Fort Resolution
SCALE
3 2 1 0 3 km.

Figure 3

water period and 2% in the winter period, was distributed through the remaining channels within the delta. Observations of very low flows or flows close to zero were recorded in some of the smaller channels during both winters of 1978-79 and 1979-80. Flows through West Channel from Old Steamboat Channel (1 on Figure 1) were found to be very minimal. Access to this site for much of the year was not possible due to extremely shallow waters in the channel. It was determined from numerous observations that there was a very small amount of water flowing in this particular channel, thus data were not computed for this channel and are not included in this report.

Percentage of flow distribution may reduce the Resdelta Channel and increase in the other channels as the volume of flow increases. This possibility is partially illustrated by the Resdelta Channel carrying up to 93% of the flow during the low flow winter period and 88% during the higher open water flow period. Unfortunately, this could not be analyzed due to the very low flows which occurred during the study period.

Table 2 lists the maximum daily discharges which occurred at Slave River at Fitzgerald from 1953 to 1980.

TABLE 2

Slave River at Fitzgerald
Maximum Daily Dishcarge
1953 to 1980

Year	Day	Daily Discharge (m^3/s)	Year	Day	Daily Discharge (m^3/s)
1953	June 15	6 230	1967	June 28	8 270
1954	June 29	8 330	1968	June 20	5 640
1955	July 1	7 390	1969	May 8	5 950
1956	June 20	6 460	1970	June 12	5 010
1957	Aug. 20	6 710	1971	July 18	6 510
1958	June 19	7 590	1972	June 18	7 700
1959	July 5	6 880	1973	June 25	6 460
1960	July 8	8 100	1974	May 5	11 200
1961	June 12	7 420	1975	July 8	6 340
1962	July 5	8 380	1976	Aug. 25	6 770
1963	June 19	7 420	1977	June 17	6 880
1964	June 19	8 670	1978	June 14	5 750
1965	July 16	8 750	1979	May 20	7 310
1966	June 18	7 140	1980	June 13	4 870

The average annual daily maximum during the 25 years preceding the study was 7 290 cubic metres per second. This average was only reached in 1979 and the maximum daily flow in 1980 was the lowest during the 28 year period of record and only three years were lower than the maximum daily discharge, which occurred in 1978. A comparison of maximum daily discharges over the period of record indicates that distribution of flow through the delta during low flow periods was well defined during the study but no knowledge was acquired with regard to flow distribution during high flow periods.

C. Suspended Sediment

Daily suspended sediment loads for stations located in the delta were not computed as daily sediment samples required for these calculations could not be obtained with available study resources. Therefore, the only sediment data available at these sites are the results obtained at the time of the measurement; however, due to the relatively smooth seasonal nature of Slave River flows, it is possible that a good correlation could be obtained between streamflow and sediment discharge. If a satisfactory correlation existed, it would be possible to produce daily sediment discharges for the various channels monitored during the delta study utilizing the daily sediment load calculated at the upstream station Slave River at Firzgerald. This analysis was not undertaken due to the limited results which could be produced from the relatively low flow conditions which existed during the study and the short period of record available, which limited defining the relationship between streamflow and sediment discharge.

The monthly mean suspended sediment load in tonnes per day for Slave River at Fitzgerald during the period of sediment record is shown in Table 3. During the 1978 to 1980 study period, the average sediment load during the period June to September was 128 000 tonnes per day, which was 22% less than the average sediment load of 164 000 tonnes per day for the same period from 1972 to 1975 and 1977.

TABLE 3

Slave River at Fitzgerald
Monthly Mean Suspended Sediment Load
in Tonnes per Day
1971 to 1980

Year	May	June	July	August	September	October
1971				87 700	48 500	35 000
1972		896 000	349 000	156 000	64 700	
1973		279 000	179 000	98 800	52 700	
1974		238 000	233 000	116 000	52 600	58 900
1975		97 000	113 000	29 400	51 500	26 800
1976	148 000	82 300	407 000	180 000		
1977	192 000	134 000	81 600	37 000	22 400	
1978	159 000	358 000	82 400	29 200	26 300	
1979		401 000	225 000	49 700	23 300	26 400
1980	39 600	197 000	95 500	22 000	20 800	30 400

The largest sediment loads occurred during 1979, which was the highest streamflow year that occurred in the study period and these were only approximately 50% of the monthly means which occurred during 1972.

Maximum daily sediment loads of Slave River at Fitzgerald for the annual period of sediment record are provided in Table 4. It is important to note that this table only addresses the period in each year when sediment records were collected and a higher daily sediment load could have occurred during 1974 and 1979 when the peak streamflow occurred during May but sediment records were not obtained.

TABLE 4

Slave River at Fitzgerald
Maximum Daily Suspended Sediment Load
1972 to 1980

Year	Day	Daily Suspended Sediment Load (tonnes per day)
1972	June 22	4 640 000
1973	June 24	558 000
1974	July 25	540 000
1975	May 16	236 000
1976	July 8	1 640 000
1977	May 19	384 000
1978	June 15	757 000
1979	June 9	691 000
1980	June 17	752 000

The maximum daily sediment load of 4 640 000 tonnes per day in 1972 was six times greater than the maximum daily sediment loads measured during the study.

D. Water Quality

A limited baseline water quality sampling program was undertaken just above the delta and the resulting data compared to the long-term data at Fort Smith. This comparison indicates the long-term data at Fort Smith is representative of the short-term delta measurements. Any input from the Salt River and other small tributary channels appear to be negligible when diluted with the much larger Slave River flows.

It was found the Slave River contains moderate amounts of dissolved solids with typical values ranging from 100 to 140 mg/L. Most metals are present at undetectable or very low concentrations with the exception of iron and manganese. Herbicides, picoloram, and most chlorinated hydrocarbons have never been detected in the waters of the Slave River.

DEPARTMENT OF INDIAN AFFAIRS
AND NORTHERN DEVELOPMENT

Northern Affairs Program, Water Resources Division
Yellowknife

C

Fisheries Studies in the Slave River Delta, NWT

Final Report

Prepared by

D.B. Tripp
P.J. McCart
R.D. Saunders
G.W. Hughs

Aquatic Environments Limited
Calgary, Alberta

Calgary, Alberta

February, 1981

EXECUTIVE SUMMARY

The Slave River Delta fisheries studies, conducted over a two year period from 1978 to 1980, were designed to provide information useful in evaluating the Delta's sensitivity to potential developments upstream and its importance to domestic and commercial fisheries elsewhere. Basically this meant providing descriptions of:

1. The life histories, seasonal movements, distribution, and relative abundance of the major fish species,
2. Seasonal variations in the species composition, distribution, and relative abundance of benthic invertebrates, and
3. Seasonal variations in water temperature, dissolved oxygen, pH, conductivity, turbidity, suspended sediments, major ions, and macronutrients.

The seasonal variations observed in water quality in the Slave River Delta were not unexpected for a large, slow flowing, turbid river in northern Canada. Turbidity and suspended sediment loads for example, were naturally highest during the spring and early summer floods (350 to 800 FTU; 1000 to 2000 mg/L, respectively), declining in late summer and fall (30 to 90 FTU; 60 to 150 mg/L), and reaching their lowest levels in late winter (less than 10 FTU;

20 mg/L). Dissolved oxygen concentrations (range 8.8 to 13.0 mg/L) were highest during early spring and late fall, the two coldest periods during the open water season, and lowest during summer, the warmest period. Water temperatures ranged from 0 C in winter to 21 C or higher in summer.

Water in the Slave River Delta is basically of the calcium carbonate type but the proportions of sodium and chloride increase during low flows in the winter. Concentrations of macronutrients are not unusual for a stream of this type. Concentrations of TDP (0.02 - 0.35 mg/L) tend to be highest during the period of high flows in June and July while concentrations of reactive silica (0.36 - 3.70 mg/L) are generally higher in the fall than in summer. TDN concentrations (0.46 - 1.02 mg/L) peaked in August but were otherwise similar throughout the sampling period. Overall, water quality in the Slave River Delta is well within the tolerance limits of even the most sensitive fish species.

Benthic invertebrate communities in the Slave River Delta are typical of those inhabiting silty substrates, the major substrate type in the delta. Aquatic worms (oligochaetes) and midges (chironomids) together dominate the benthos, particularly in shallow water where benthic invertebrate densities are highest. In deeper water, oligochaete and chironomid numbers fall off and mayfly nymphs and caddisfly larvae are relatively more common. Overall, benthic macroinvertebrate densities are highest in fall and lowest in spring with the greatest differences occurring in shallow water.

A total of at least 24 fish species utilize the Slave River Delta, one of which is a small bodied cisco that comes in two forms. The first form, with the smallest body size, is characterized by white pelvic fins, while the second form, with a larger body size, is characterized by black pelvic fins. Since both forms share the same spawning time and spawning place in the delta, and both forms show complementary growth curves, they were initially thought to be dominant year classes of the same species, a species whose pelvic fins get progressively darker with age. Recent electrophoretic analyses suggest, however, that there may be in fact two separate species after all, both of which get progressively darker fins with age.

Eight species are relatively rare in the Slave River Delta and should probably be considered as incidental. These include the Arctic grayling and slimy sculpin, both of which are usually associated with clear, rubble-bottomed streams, and the large bodied lake ciscos which are more closely associated with Great Slave Lake. Others, like pearl dace, ninespine sticklebacks, and yellow perch, are probably fish which have wandered downstream out of small streams and lakes draining into the Slave River, while spottail shiners and white suckers could be related to larger populations in both Great Slave Lake and the upper mainstem Slave River.

In contrast to the relatively uncommon species listed above, northern pike, lake chub, emerald shiners, flathead chub, and trout-perch are abundant in the delta for most of the open water period. Although data are scarce, these species do not appear to undertake extensive migrations and probably represent fish which remain in the vicinity of the delta and lower Slave River year-round.

Aside from fish which rarely use the delta and those which use the delta year-round, there are eight important species which can be separated into one of three categories:

1. Fish that migrate through the delta,
2. Fish that feed in the delta, and
3. Fish that spawn in the delta.

The first category includes inconnu, lake whitefish, and probably spoonhead sculpins. As adults, these fish do not feed or spawn in the delta but, instead, migrate through the delta to spawning and feeding areas located elsewhere.

Spoonhead sculpins probably migrate upstream through the delta in early spring, in some years probably before breakup. Their spawning areas are unknown. Inconnu and lake whitefish appear to migrate upstream through the delta in late summer and early fall. Their major spawning areas are believed to be upstream, in the vicinity of the rapids at Fort Smith, where large concentrations of both species occur during late fall.

Some lake whitefish apparently return to Great Slave Lake shortly after spawning while others remain to overwinter in the Slave River, returning to Great Slave Lake the following spring. Most inconnu, on the other hand, apparently move back to Great Slave Lake shortly after spawning since very few are captured in the river in the spring and summer. The movements of young-of-the-year inconnu are unknown while young-of-the-year lake whitefish drift downstream to Great Slave Lake shortly after emergence. Depending on how fast the delta clears of ice, they may also feed for a short period in the delta.

Goldeye, longnose suckers, and walleye fall into the second category which includes fish that spawn elsewhere and then return to feed in the delta for most of the open water period. The results of tag recoveries, late winter netting under the ice, and seasonal variations in spawning condition indicate that both longnose suckers and walleye migrate upstream from Great Slave Lake to spawning areas in the Slave River before breakup in the Slave River Delta. Some return to feed in the delta shortly after spawning while otners return in early fall to feed before continuing on to overwintering areas in Great Slave Lake. Goldeye on the other hand are believed to be closely related to goldeye populations in the upper Slave River region. Instead of moving upstream out of Great Slave Lake like walleye or longnose suckers, they are thought to move downstream into the delta after spawning, returning upstream in the fall.

Burbot and small bodied ciscos fall into the third category which includes major fish species that spawn in the Slave River Delta. Their principal spawning areas appear to be Resdelta Channel and the lower reaches of the Slave River. Ciscos move into the delta in late fall, spawn in late October, and presumably return to the lake after freeze-up. Burbot accompany the ciscos and spawn from freeze-up to late December. Although it is likely that most return to Great Slave Lake, some burbot also evidently move upstream as far as Fort Smith after spawning. Young-of-the-year burbot normally rear in the delta after emerging while young-of-the-year ciscos probably rear in Great Slave Lake.

Goldeye, pike, longnose suckers, burbot, and walleye together dominate the catch in variable mesh gillnet gangs and thus best typify the large fish fauna of the Slave River Delta.

Interestingly, three of these species (pike, burbot, and walleye) are piscivorous predators while another (goldeye) is an opportunistic feeder well adapted to feeding in the turbid waters of the Slave River. Since the longnose sucker appears to be the only large fish species present that is adapted to feeding on the benthic invertebrate fauna, small fish species, largely represented by emerald shiners, lake chub, and trout-perch, are probably a more important link in the transfer of energy from the delta's invertebrate community to larger fish.

With the exception of goldeye, large fish tend to be three or four times more abundant in the lower Slave River and Resdelta Channel than elsewhere in the delta. Goldeye are more evenly distributed as are most of the small fish species, including young-of-the-year of larger species like pike and burbot. Overall, the highest densities of small fish are recorded in shallow, well vegetated habitats where a suitable combination of protective cover and food is provided. Shallow, barren habitats have enough food but no cover, while deep, vegetated areas have sufficient cover but less food.

Seasonally, the largest concentrations of small fish occur in late spring and summer when young-of-the-year densities are highest. Large fish, on the other hand, are most abundant in early spring and late fall when the majority of spawning, post-spawning, feeding, and overwintering migrations occur. Late winter surveys indicate that little activity occurs in March, but by April, spring spawning fish are beginning to move upstream.

Annual variations in gillnet catches are thought to reflect changes in sampling efficiency more than changes in fish abundance. In 1980, for example, breakup was almost a month earlier than in 1979, thus allowing the field crew to more efficiently sample fish during their spring spawning and post-spawning migrations. As another example, the larger gillnet catches of small bodied ciscos in 1979 compared to 1978 are thought to be the result of an overall increase in their average fork length and thus their susceptibility to capture in gillnets.

Annual variations in the abundance of small fish are believed to be more significant biologically. Young-of-the-year pike and burbot were abundant in 1979 but not in 1980, while lake whitefish and spoonhead sculpin young-of-the-year were common in 1980 but not in 1979. Others, like trout-perch, were considerably more abundant in 1980 than in 1979, while lake chub, flathead chub, and emerald shiners all showed a decline in 1980.

The number of large fish actually present in the Slave River Delta is, on the average, comparatively small. The delta therefore has little significance as a domestic fishing area other than when burbot are spawning, and only then when hunting is exceptionally good. Better domestic fishing areas are located in other tributaries of Great Slave Lake (the Little Buffalo and Taltson rivers), Great Slave Lake itself (Resolution Bay), and the upper Slave River (near Fort Smith).

The Slave River Delta is not an important feeding area for large fish, nor does it appear to be any more important than the mainstem Slave River as a rearing and feeding area for small fish species. It is, however, important as:

1. A migratory pathway between Great Slave Lake and the upper Slave River for what are probably large numbers of important commercial, domestic, and sport fish species, including lake whitefish, inconnu, longnose sucker, and walleye;

2. A critical fall spawning area for extremely large numbers of small bodied ciscos, themselves an important plankton feeder in Great Slave Lake and possibly even more important as a forage species for more desirable fish like lake trout;

3. A critical spawning area for large numbers of burbot, an important predator in Great Slave Lake; and

4. A rearing area for young-of-the-year burbot and pike.

Most of the effects of hydroelectric dams and reservoirs on the ecology of the Slave River Delta will probably result from a reduction in nutrient loading rates, suspended sediment loads, and peak flood levels. The last two effects, if severe enough, could result in a smaller delta.

Large fish species which now migrate through (lake whitefish, inconnu, longnose sucker, walleye), feed in (goldeye), or spawn in (ciscos, burbot) the delta would be relatively unaffected as adults by a smaller delta. Although a major portion of their present feeding and rearing areas would be lost, most small species would be similarly unaffected since substantial spawning, rearing, and feeding areas would still exist elsewhere for these widespread species. Burbot populations, on the other hand, could be reduced over a wide area if the present rearing areas in the delta represent a significant fraction of total young-of-the-year production in the Great Slave Lake region.

A reduction in nutrient loading rates would affect primary and higher trophic levels, the latter including fish. Its effects are therefore likely to affect a much wider area than just the Slave River Delta. In time, reduced nutrient loading rates in Great Slave Lake could result in an overall decrease in fish production.

Several recommendations are made for further study. In our view, the most important of these are studies of the spawning times and spawning areas of lake whitefish and inconnu in the Slave River near Fort Smith. Because of the large concentrations of fish which occur there, such studies would probably provide the best opportunity to tag the large number of fish required to adequately assess the importance of the Slave River to commercial and domestic fisheries in Great Slave Lake.

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Chapter I

INTRODUCTION

River deltas are among the most productive of aquatic habitats as a result of high nutrient loading rates, extensive shoreline development, and considerable habitat diversity. All of these factors are closely related to the hydrological conditions which form deltas in the first place, and are, therefore, naturally sensitive to any changes in the hydrological regime.

The Slave River Delta is the smallest and least studied of the three major deltas in the Mackenzie River Basin. At present an important source of food and furs to the people of Fort Resolution, the Slave River Delta is also likely to be important as a spawning and rearing area for various fish species inhabiting Great Slave Lake, including those important to the domestic and commercial fisheries of the region.

This study of fish populations in the Slave River Delta is designed to provide information which can be used to assess the potential effects of future developments in the river basin. The specific objectives of the study were:

1. To obtain baseline information on the life histories of fish populations utilizing the Slave River Delta;

2. To provide baseline data on the physical, chemical, and biological characteristics of aquatic habitats in the Delta and to document the relative importance of those habitats to fish populations so that pre-development data can be used as a basis for post-development evaluations;

3. To evaluate the local, regional, and national significance of the aquatic resources of the Delta;

4. To obtain sufficient information to enable the identification of study needs of a more intensive nature, if and when developments are proposed for the Slave River drainage.

To meet these objectives, field studies on the fisheries of the Slave River Delta were conducted over a two year period, from the fall of 1978 to the summer of 1980. During this period, intensive field studies were conducted over six to eight week periods in the fall and spring with shorter, one to two week long studies in late winter and summer. Interim reports of limited distribution were prepared, summarizing the results of the fall field studies in 1978 (McCart, Tripp et al. 1978) and the winter, spring, summer and fall studies of 1979 (Tripp et al. 1980). This, the final report, includes much of the preliminary results presented in the interim reports as well as the results of the studies conducted during the winter, spring, and summer of 1980.

Chapter II

THE STUDY AREA

A. General Description

The Slave Delta is located midway along the south shore of Great Slave Lake at 61°15'N latitude and 113°35'W longitude, approximately 10 km north of Fort Resolution (Figure 1). The active portion of the Delta has a triangular shape, 20 km in length along its interface with Great Slave Lake, and 10 km deep, from Great Slave Lake to the head of the Delta. The total area encompassed by the active Delta is approximately 75 km square, including four major channels. Resdelta Channel on the north side of the Delta is by far the largest and most important of these (Figure 2), followed by East, Middle, and Old Steamboat channels to the south. A number of minor interconnecting channels such as "Whiteman's" and "Four Way" are important as routes for people passing across the Delta.

The Jean River which originates 14.5 km upstream and flows to the north of the presently active Delta, and Nagle Channel, which originates 3.5 km upstream and flows to the south, mark the outer boundaries of the Slave River Delta. Unlike major channels in the central, more active areas of the Delta, the Jean River and Nagle Channel appear stable, with few signs of erosion or extensive flooding. They are separated from the main part of the

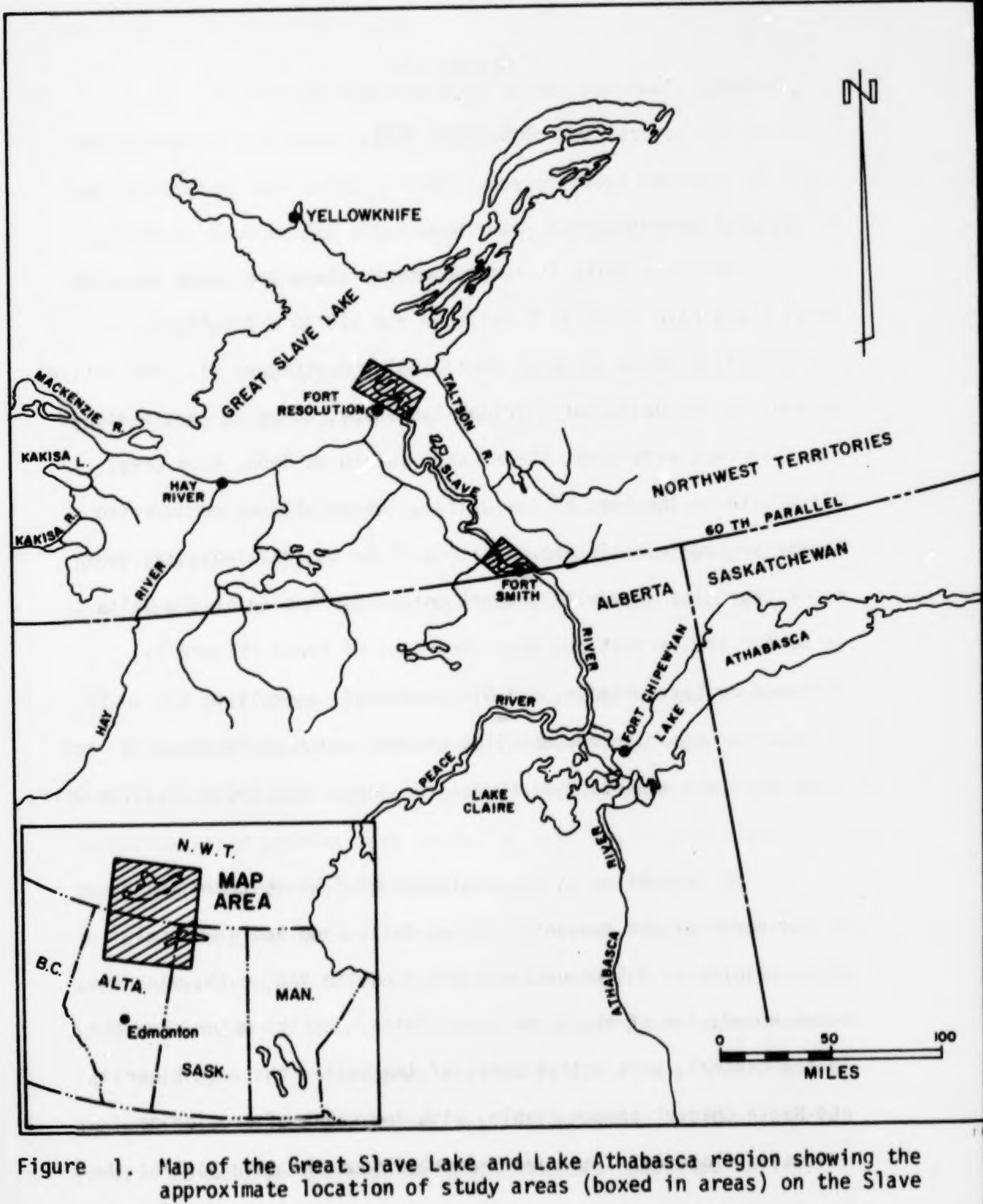
N
YELLOWKNIFE
GREAT SLAVE LAKE
MACKENZIE R.
FORT RESOLUTION
TALTSON R.
SLAVE
KAKISA L.
HAY RIVER
KAKISA R.
NORTHWEST TERRITORIES
60 TH PARALLEL
FORT SMITH
ALBERTA
SASKATCHEWAN
RIVER
HAY
RIVER
FORT CHIPEWYAN
ATHABASCA
LAKE
PEACE
RIVER
LAKE CLAIRE
RIVER
ATHABASCA
N.W.T.
MAP AREA
B.C.
ALTA.
MAN.
Edmonton
SASK.
0
50
100
MILES

Figure 1. Map of the Great Slave Lake and Lake Athabasca region showing the approximate location of study areas (boxed in areas) on the Slave River.

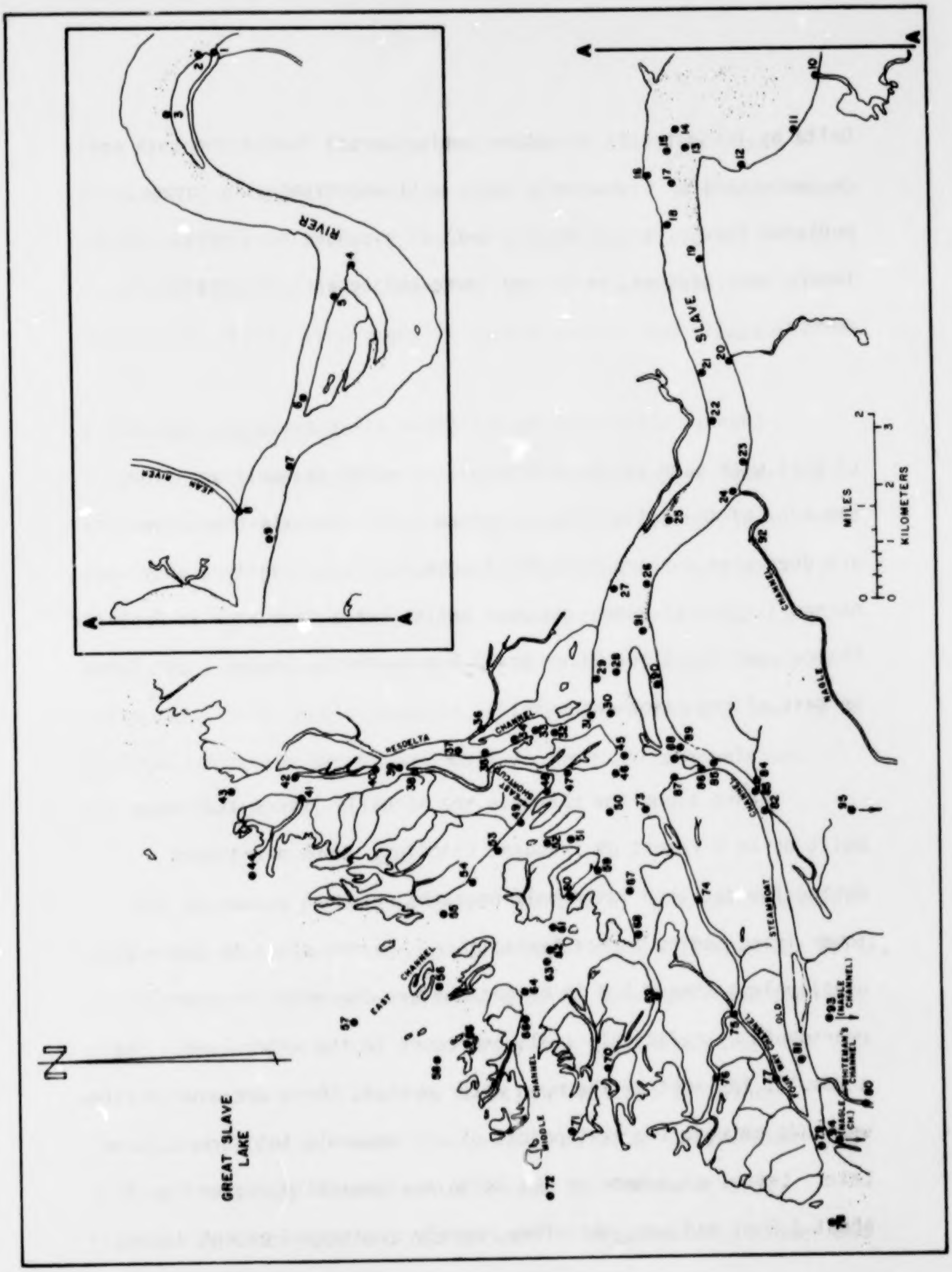
GREAT SLAVE LAKE
SLAVE
RIVER
JEAN RIVER
RESDELTA CHANNEL
EAST CHANNEL
MIDDLE CHANNEL
STEAMBOAT CHANNEL
OLD STEAMBOAT CHANNEL
NAGLE CHANNEL
WHITEMAN'S CHANNEL
MILES
KILOMETERS
0
1
2
3
A

Figure 2. The study area showing the location of all sampling sites in the Slave River Delta and lower Slave River. An explanation of the various activities and parameters sampled at each site is given in Table 1.

Delta by large tracts of mature poplar-spruce forest and both are characterized by high stable banks well vegetated with spruce, poplars, shrubs, and a dense growth of overhanging alders. In their lower reaches, banks are lower and aquatic vegetation is common.

Channel substrates in the Slave River Delta are composed of silt with sand in the middle of the major channels and along the edge of the delta-lake interface. The channels themselves are deep with a sharp dropoff alongshore, resulting in a very narrow "littoral" zone. Maximum depths range from 32 m in Resdelta Channel and the Slave River to 12.5 m in Middle Channel, and 2.0 m in most of the minor channels.

Banks along the channels are actually levees that have built up as a result of frequent flooding. When overtopped during floods, they later hold back the receding waters in the lower lying basins formed behind them. Levees close to lakes are usually less than 0.3 m in height and are therefore frequently overtopped by relatively small increases in the water level. As a result, for most of the open water period, there are wide shallow wetlands between the exit points of all channels into Great Slave Lake. Levees elsewhere in the Delta are generally higher (up to about 1.0 m) and are, therefore, rarely overtopped except during high spring floods. The exceptions are, one, the low levees located along recently formed islands or channels, and two, the exceptionally high levees (2 to 3 m or so high) along the Slave River and upper Resdelta Channel. The latter are rarely if ever topped and usually show signs of severe erosion and slumping.

B. Aquatic Vegetation

Aquatic macrophytes provide spawning areas, a food-rich habitat, and protective cover for a number of fish species. In the Slave River Delta, the dominant underwater macrophytes are, in decreasing order of importance, *Potomogeton pectinatus* (Sago Weed), *P. richardsoni* (Clasping-Leaf or Pickeral Weed), and *P. gramineus*. Only rarely abundant, all three are found primarily in shallow, protected areas along most of the major channels and the outer Delta.

Equisetum fluviatale (River Horsetail) is by far the most common emergent aquatic macrophyte present in the Slave River Delta, and therefore likely to provide more cover for small fish than any plant. Sedges (*Carex* spp.) and cattails (*Typha latifolia*) are next in abundance, followed by occasional patches of rushes (*Scirpus* sp.) and bur-weed (*Sparganium* sp.). Willows predominate in less frequently flooded areas beyond the ice scour zone followed by alder, poplar, and spruces in progressively higher and dryer habitats.

C. Climate

The Slave River Delta lies in a climatic zone called the Boreal Forest by Burns (1973). It separates the harsher taiga and tundra regions around Great Slave Lake to the east and north, and the sub-boreal forest regions of the upper Mackenzie and Liard River drainages to the west. Like most of the western Northwest Territories, its' climate is dominated by cold continental Arctic air masses during the winter, and warmer maritime Arctic air during summer. Although moderated slightly by Great Slave Lake, warm tropical air occasionally moves up from the south as well, pushing summer temperatures into the high twenties (°C) for short periods. The mean annual temperature is -4.1°C, ranging from monthly mean temperatures of -26.3°C in January to 15.7°C in July. Total annual precipitation averages only 29.6 cm, 15.8 cm in the form of rain, and 13.8 cm in the form of snow.

D. Hydrology

The Slave River Delta is the result of sediment deposits caused by a reduction in the Slave River's current speed when it enters Great Slave Lake (Reid 1961). Differences between the amount of sediment deposited and the amount of sediment lost due to wave action and lake currents determine whether or not the Delta is growing, shrinking, or just holding its own. Mid-channel deposition results in the characteristic branching and occasional rejoining of channels separated by islands.

Flood waters in a delta recharge and freshen the water supply of isolated basins and abandoned stream channels, enhance the fertility of flood plains with a layer of silt, and generally maintain the vegetation over large areas of an early successional stage. Davies (1980) indicates that in the Slave River Delta, ice-jamming during spring breakup causes the greatest flooding, followed by a second peak in June or July, resulting from mountain run-offs in the Peace and Athabasca River drainages. Heavy storms or unusually strong winds can also cause seiches (wind tides) on Great Slave Lake, raising water levels in the Delta by 0.2 to 0.4 m.

Spring breakup in the Slave River Delta usually occurs during the first and second weeks of May, but may occur in late April or in late May. Freeze-up generally occurs in early November.

On an annual basis, Resdelta Channel accounts for about 86% of the flow through the Delta, Middle Channel (west branch) for 6% and the rest of the channels for 8% (Davies 1980). There is zero flow in some of the smaller channels during winter.

E. Sampling Sites

Figure 2 shows the location of all study sites in the Delta and on the Slave River upstream to a point about 14 km above the Jean River. Of the 95 study sites indicated, 43 were used for gillnetting, 23 for beach seining, 47 for minnow seining, and 15 for set lines. During the fall of 1978, two fish traps were operated, one on Resdelta Channel approximately 3 km upstream of its mouth, and one on the Slave River approximately 6 km upstream of its confluence with Nagle Channel. Benthic macroinvertebrates were sampled at 21 sites scattered throughout the Delta, including the delta-lake interface, several minor channels, and all of the major channels. Fry drift and water quality samples were collected in the mainstem Slave River near the head of the Nagle Channel.

Table 1 summarizes the type of sampling conducted at each station. It does not include the short-term fishery surveys conducted on the lower reaches of the Salt River (spring 1979) and on the Slave River at Rapids of the Drowned (fall 1979) near Fort Smith.

Table 1. A summary of the type of sampling done at each station shown on Figure 2.

Station Number	Location	Type of Sampling							
		Gillnets	Beach Seines	Minnow Seines	Set Lines	Traps	Drift Samples	Benthos	Water
1	Slave		x						
2	"		x						
3	"		x						
4	"		x						
5	"	x		x					
6	"		x						
7	"		x						
8	"	x		x	x				x
9	"		x						
10	"	x		x					
11	"	x							
12	"	x							
13	"	x							
14	"	x							
15	"	x	x						
16	"	x							
17	"	x		x		x			
18	"	x		x	x				
19	"	x							
20	"	x							
21	"	x		x	x				
22	"	x							
23	"	x			x		x		
24	"	x		x	x				x
25	"	x							
26	"	x			x				
27	"	x							
28	"	x							
29	"	x							
30	"	x							
31	Resdelta	x			x				

Continued

Table 1. Continued.

Number	Location	Type of Sampling							
		Gillnets	Beach Seines	Minnow Seines	Set Lines	Traps	Drift Samples	Benthos	Water
32	Resdelta	x		x				x	x
33	"	x	x	x	x				
34	"	x							
35	"	x							
36	Minor							x	
37	Resdelta			x					
38	"	x	x	x					
39	"	x			x	x		x	x
40	"	x							
41	Minor			x					
42	Resdelta			x					
43	Resdelta							x	
44	Minor			x					
45	Middle							x	
46	East Shortcut		x	x					
47	" "		x	x					
48	" "							x	
49	" "		x						
50	East			x					
51	"			x					
52	"			x					
53	East Shortcut			x					
54	East	x		x	x			x	x
55	"	x							
56	"			x					
57	"							x	
58	"	x	x					x	
59	Middle			x					
60	"		x	x					
61	"		x	x					

Continued

Table 1. Continued.

Station Number	Location	Type of Sampling Gillnets	Beach Seines	Minnow Seines	Set Lines	Traps	Drift Samples	Benthos	Water
62	Middle		X	X					
63	"	X			X			X	
64	"	X	X	X	X				
65	"		X						
66	"			X					
67	"			X					
68	"							X	
69	"			X					X
70	"	X		X	X				
71	"		X	X				X	
72	"							X	
73	Four Way			X					
74	"			X					
75	"	X		X					
76	"		X	X					
77	"			X				X	
78	Steamboat							X	
79	"	X							
80	Whiteman's		X	X					
81	Steamboat			X				X	
82	"			X					
83	"								X
84	Minor							X	
85	Steamboat	X						X	
86	"	X			X				
87	"			X					
88	"			X					
89	"		X	X					

Continued

Table 1. Continued.

Number	Location	Type of Sampling Gillnets	Beach Seines	Minnow Seines	Set Lines	Traps	Drift Samples	Benthos	Water
90	Steamboat			x					
91	"	x							
92	Nagle	x		x	x			x	
93	"							x	
94	"			x					
*95	"			x				x	

*new site in 1980 because at site #92 water levels too low and drop off too steep

#95 - Lower Nagle - Nagle Channel, south side of channel, left bend heading towards the landing

Chapter III

MATERIALS AND METHODS

A. Timing of Major Events

Table 2 summarizes the timing of various activities undertaken in this study. In the Slave River Delta, the most intensive studies were conducted during the fall and spring periods, from September 12 to November 7 in 1978, from May 24 to July 13 and September 26 to October 26 in 1979, and from May 9 to June 30 in 1980. Shorter, less intensive surveys to determine the distribution and relative abundance of fish in late-winter and mid-summer were conducted from March 12 to 19 and August 21 to 31 in 1979, and from April 11 to 22 and July 19 to August 7 in 1980. During our field crew's absence, gillnetting was continued by a local assistant in an attempt to maintain a continuous record on fish movements.

Two additional surveys were conducted near Fort Smith in 1979, on the Salt River during spring, May 28 to 31 and June 12 to 17, and on the Slave River during fall, October 1 to 10. Both were done to tag additional fish at a time when catches in the Slave River Delta were very low. The fall study also provided an opportunity to assess the possibility of lake whitefish and inconnu spawning in the Slave River in the vicinity of Rapids of the Drowned.

Table 2. Summary of field activities in the present study.

Time Period	Gillnetting	Beach Seining	Minnow Seining	Set Lines	Fish Traps	Tagging	Fry Drift	Benthos Studies	Water Quality
Slave Delta									
1978									
Sept. 12 to Nov. 7	+	+		+	+	+		+	+
1979									
March 12 to 19	+			+					+
May 28 to July 13	+	+	+	+		+	+		+
July 14 to Aug. 20	+								
Aug. 21 to Aug. 31	+	+	+	+		+			+
Sept. 1 to Sept. 25	+								
Sept. 26 to Oct. 26	+		+	+		+			+
Oct. 27 to Nov. 5				+					
1980									
April 11 to 22	+			+					+
May 9 to June 30	+		+			+	+	+	+
July 1 to 28	+								
July 29 to Aug. 7	+		+			+		+	+
Fort Smith									
1979									
May 28 to 31	+	+				+			
June 12 to 17	+	+				+			
Oct. 1 to 10	+	+				+			

B. Water Quality Studies

At seven to ten day intervals during each field trip, water quality samples were taken from mid-channel in the Slave River, just upstream of Nagle Channel (Figure 2, Table 1). Other sites located throughout the Delta were sampled during the late winter surveys only.

Water samples taken for later anaylsis in the laboratory were collected in new 0.5 L plastic bottles and, in 1978, preserved with either 1 mL $CHCl_3$ (for pH and conductivity measurements) or 1 mL $CuSO_4$ solution (for turbidity and suspended sediment concentration determinations). Similar collections were made in 1979 and 1980, but without the addition of preservatives so that major ion (Na^+, K^+, Mg^{++}, Ca^{++}, Cl^-, $SO_4^=$, HCO_3^-, and macronutrient (TDN, TDP, S_iO_2) concentrations could be determined as well. Table 3 summarizes the methods used in analysing water samples.

C. Macroinvertebrate Studies

Benthic macroinvertebrates in the Slave River Delta were sampled with an Eckman or Ponar grab at 20 stations in the fall of 1978, and at 14 stations in the spring of 1980 (Table 4). One to three sites, depending on the width and depth of the channel, were sampled at seach station, taking three replicates at each site. Each sample was rinsed through a 600 μ mesh seive and preserved for later analysis.

Table 3. Methods of physical and chemical analysis for water quality in the Slave River Delta.

Parameter	Methods	Source of Method	Modifications
Ca, Mg	Atomic absorption	Instrumentation Laboratories Model 151 aa/ae spectrophotometer	None
Na, K	Atomic absorption	Instrumentation Laboratories Model 151 aa/ae spectrophotometer	Li suppression of ionization
SO_4	Turbidimetric method	Standard Methods for the Examination of Water and Wastewater 13th Ed. (1971)	Plunger mixing Hach Turbidimeter Model 2100A
Cl	Argentometric titration	Standard Methods for the Examination of Water and Wastewater. 13th Ed. (1971)	None
Alkalinity System (HCO_3)	Acid titration	Standard Methods for the Examination of Water and Wastewater. 13th Ed. (1971)	pH meter replaces mixed indicator
SiO_2	Heteropoly blue	Standard Methods for the Examination of Water and Wastewater. 13th Ed. (1971)	None
TDN	Ultraviolet photochemical oxidation followed by Amalgamated Cadmium Column	Strickland and Parsons (1968)	Sample filtered; overnight (15 hr.) irradiation period using a 550 watt lamp

Continued

Table 3. Concluded.

Parameter	Methods	Source of Method	Modifications
TDP	Persulphate digestion	Standard Methods for the Examination of Water and Wastewater. 13th Ed. (1971)	Sample filtered
Conductivity	meter	Beckman Solu-bridge	None
Turbidity	Nephelometry	Measured at FTU using a Hach Model 2100A Turbidimeter	None
Suspended Sediments	Filtration and drying	Standard Methods for the Examination of Water and Wastewater. 13th Ed. (1971)	Dried at 180 C
pH	combined electrode type	Radiometer pH meter Type 296	None
Dissolved Oxygen[a]		Hach-Kit OX-10	Long method
Temperature[a]	Handheld thermometer, Taylor maximum/minimum recording thermometers		None

[a] Parameters determined in the field

Table 4. Summary of benthic macroinvertebrate sampling stations in the Slave River Delta, 1978 (fall) and 1980 (spring). The location of each sampling station is shown in Figure 2.

Channel	Station Number	Number of sites at each station	Dates Sampled	
			1978	1980
Resdelta	32	3	Oct 6	June 14
"	36	2	Oct 1	*
"	39	3	Oct 5	June 14
"	43	3	Oct 5	June 15
Slave	45	3	Oct 2	*
East	48	2	Oct 2	June 15
"	54	2	Oct 2	June 13
"	57	2	Sept 24	*
"	58	2	Sept 24	June 13
Middle	63	2	Sept 21	June 13
"	68	2	Sept 21	June 12
"	71	2	Sept 21	*
"	72	2	Sept 21	June 13
"	77	2	Sept 21	June 15
Steamboat	78	2	Sept 21	June 12
"	81	2	Sept 21	*
"	84	1	Sept 21	*
"	85	2	Sept 21	June 12
Nagle	92	1	Sept 25	June 11
"	93	3	Sept 26	*
"	95	2	*	June 13

* Not Sampled

Standardized net sweeps were also used to qualitatively sample the macroinvertebrates at 26 minnow seining stations, August 1 to 6, 1980. This was done to provide, one, a description of the macroinvertebrate fauna missed by grab samples near shore, and two, some idea of what the relationships might be between generalized nearshore habitat types, food availability, and fish abundance. Two sweeps, one in 0.3 m of water and the other in 1.0 m of water, were made at each station and combined into a single sample before being preserved for later analysis. Vegetative cover, substrate composition, depth and bottom slope were regularly recorded at all minnow seining stations

All samples were preserved in 10% formalin with 100 mg/L Rose Bengal stain solution added to assist sorting. In the laboratory, invertebrates were sorted under a binocular microscope, enumerated, and identified to the lowest possible taxon (genus and species for most groups, family for many of the Diptera). The major taxonomic references used included Brooks and Kelton (1967), Edmunds et al. (1976), Edmondson (1959), Hamilton and Saether (unpublished keys), Merrit and Cummins (1978), Oliver et al. (1978), Pennak (1978), Usinger (1963), and Wiggins (1977).

D. Fish Studies

1. Fish Collections:

Adult and juvenile fish in the Slave Delta were sampled throughout the study period using a variety of techniques (Figure 2, Table 1). These included: (a) 3.0 and 6.0 m pole-mounted minnow seines; (b) standard 18.3 and 45.7 x 2.4 m monofilament gillnets made up of six equal panels of six different mesh sizes (3.8, 5.1, 6.4, 75., 8.9, and 10.2 cm stretch mesh); (c) a 30 m long beach seine with a 5.1 cm stretch mesh; and (d) set lines consisting of from 12 to 100 hooks attached on 20 cm long monofilament gangions set at 1 m intervals. Records were kept of both catches and sampling effort (number of beach seine hauls, length of shoreline seined, the number of gillnet hours and the number of set line hours) in order to compare catches at different times and at different locations. The duration of the 45.7 m gillnet sets was multiplied by a factor of 2.5 so that catches per unit effort (CPUE) in the longer (45.7 m) nets would be comparable to CPUE in the shorter (18.3 m) nets. Fishing effort for set lines was determined by multiplying the length of time each line was set by the number of hooks on the line.

In the fall of 1978, two fish traps were established, one on Resdelta Channel and one on the Slave River (Figure 2, Table 1).

They were 2.4 m long, 2.4 m wide, and 1.5 m high. The floors were constructed of 1.8 cm thick plywood and the walls of 1.2 cm hardware cloth stretched over wooden frames. A partition down the middle of each trap divided it into an upstream and downstream portion with two doors on each section. The opening between the two doors in each section was adjusted by placing steel stakes in one of a series of holes located on the downstream side of each door. Trap wings were constructed of 2.5 cm mesh chicken wire and extended from the traps into shore and into the river of a depth of 1.2 m.

The Slave River trap was installed on September 12 and removed on November 11. The Resdelta trap was installed on September 19 and removed on November 9. When conditions permitted, both traps were checked at least daily, more often when there were large numbers of fish being captured.

2. Treatment of Samples:

All fish captured in gillnets, beach seines, or set lines were either retained for detailed life history analysis or released alive after being measured to the nearest mm in body length. Fish taken by the fish traps were treated in a similar manner except when large numbers of fish were present. Then, all fish were counted but only subsamples were taken for life history analysis and body length measurements.

All fish larger than 210 mm which appeared to be in good condition were tagged with consecutively numbered Floy Dart tags. Tagged fish which were recaptured had their tag numbers recorded and were released again if in good condition. Posters advertising a two dollar reward for the return of the tags, including information on the date, location, and method of capture, were distributed to all communities around Great Slave Lake and along the Mackenzie and Slave rivers.

Fish taken in minnow seines were identified, enumerated, and subsampled for body length measurements before being released. Samples which were exceptionally large or which contained fish that were difficult to identify under field conditions were subsampled (1/4, 1/3, 1/2) and preserved in 5% formalin for later inspection in the laboratory. In the laboratory, samples were identified, measured for body length, and further subsampled for an analysis of stomach contents.

3. Fry Drift Sampling:

During spring studies, three to six replicate drift samples were taken from the middle of the Slave River (Table 1, Figure 2) at one to three day intervals for the purpose of collecting newly emerged fry. The sampling apparatus was a simple drift net one metre in length, constructed of 505 μ mesh Nitex netting. It had a 30.5 cm square opening and tapered to a 0.5 L, wide mouthed, plastic collecting bucket with 600 μ meshed Nitex covered windows.

The apparatus was generally operated just below the surface of the water for a period of 5 to 10 minutes. Longer sampling periods were not possible because of the large amounts of debris present in the river. Both time and current velocity through the net were recorded at the beginning and end of the drift sample in order to relate the number of fry captured to the total volume of water sampled. Samples were preserved in 5% formalin and later sorted in the laboratory under a binocular microscope. References used for the identification of newly emerged fry included Battle and Sprules (1960), Faber (1970), Fish (1932), and Norden (1961).

4. Life History Analysis:

Fish sampled for life history analysis were measured to the nearest mm body length (total length for burbot and sculpins, fork length for all other species) and weighed on a triple beam balance to the nearest 0.1 g for smaller fish and the nearest 1.0 g for large individuals. Sex and maturity were recorded and the gonads of females weighed to the nearest 0.1 g. Ten eggs, representative of the most mature size class, were removed and aligned on a millimetre scale to provide an index of egg size. Ovarian subsamples were taken from various parts of the gonad, weighed, then preserved in 10% formalin. For most species, these subsamples average about 10% of total ovarian weight. For two species, the inconnu and burbot which have very large gonads, the subsamples averaged only about 1% of the total gonad weight. Total fecundities were estimated by direct proportion from the subsample egg counts.

Otoliths were removed from all species except walleye and northern pike, then stored in vials containing glycerine for later age determination in the laboratory. Opercular bones were taken from walleye, cleaned, and stored in coin envelopes while scales were removed from below the dorsal fin of pike, cleaned, and mounted between two microscope slides. In the laboratory, otoliths and opercular bones were examined against a dark background under a binocular microscope. Normally, the otoliths of lake whitefish, inconnu, ciscoes, and flathead chub could be read without any additional preparation. The otoliths of longnose suckers and goldeye on the other hand, all had to be polished on a carborundum stone before reading. Burbot otoliths were broken in half and read on end. Pike scales were projected on a white background and read at a power of 45x.

Otoliths, opercular bones, and scales were all examined once by an experienced observer and the age recorded. Questionable readings were examined a second time and, if necessary, a third time to resolve any differences between the first two readings. Criteria for the identification of annuli on otoliths were those of Nordeng (1961), on scales, Lagler (1956), and on opercular bones, Campbell and Babaluk (1979).

The percent fullness of stomachs was estimated visually and the contents identified to major taxa (e.g., order, family) or other suitable category (e.g., insect parts, fish remains, vegetable matter, digested material) without regard to relative abundance. These data indicate the frequency of occurrence of various food items and the range of food items consumed.

Chapter IV

WATER QUALITY STUDY RESULTS

Water quality was not a primary focus of these studies but a range of water quality parameters was examined. The results are presented below.

A. Physical Parameters

Data describing physical quality parameters (pH, conductivity, dissolved oxygen, temperature, suspended sediments and turbidity) are presented in Table 5.

1. pH:

All of the recorded values were slightly alkaline, ranging from 7.3 (May 18 and June 1, 1980) to 8.4 (June 29, 1980) with a mean of 7.8.

2. Conductivity:

Specific conductivity averaged 203 μmhos with a range of 115 to 261 μmhos. In 1979, conductivity tended to be highest during the period of high water in June while in 1980, the reverse was true. This may be the result of differences between the two years in the relative contribution of water from the Peace and Athabasca Rivers. In 1980, discharges in the Peace River were unusually low.

Table 5. Variation in physical water quality parameters, Slave Delta River, September 1978 to August 7, 1980.

Date	pH (units)	Conductivity (µmhos/cm)	Dissolved Oxygen (mg/L)	Temperature (°C)	Suspended Sediments (mg/L)	Turbidity (FTU)
			1978			
Sept 12	7.5	242	10.2	13	72	28
Sept 16	7.6	180	10.2	12	75	31
Sept 22	7.4	210	10.4	11	103	38
Sept 30	7.4	194	10.0	10	116	61
Oct 7	7.8	206	-	7.5	150	70
Oct 15	7.9	183	10.6	5.5	80	35
Oct 22	8.0	188	11.6	3.5	88	32
Oct 28	8.1	172	12.0	2.5	116	44
Nov 3	8.2	124	12.0	1.5	118	34
Nov 10	7.8	181	13.0	0.0	67	35
			1979			
March 12	8.0	188	10.5	0.0	29	10
13	7.5	190	-	0.0	21	11
15	7.7	188	-	0.0	19	10

Continued

Table 5. Continued

Date	pH (units)	Conductivity (µmhos/cm)	Dissolved Oxygen (mg/L)	Temperature (°C)	Suspended Sediments (mg/L)	Turbidity (FTU)
March 16	7.8	190	-	0.0	18	28
March 18	7.6	190	-	0.0	21	13
March 19	7.4	187	-	0.0	50	18
June 3	8.0	238	10.0	11.5	1290	740
June 10	8.0	261	9.2	11.0	2000	845
June 17	8.0	249	9.6	15.0	1570	573
June 24	8.2	226	8.8	17.0	1100	351
July 1	8.1	255	9.2	18.9	1350	775
July 8	8.0	238	9.0	21.0	660	198
August 21	7.9	202	9.0	15.0	85	97
August 29	7.7	190	9.4	10.0	60	64
Sept 23	7.9	202	11.2	11.5	48	29
Sept 30	8.0	208	10.6	10.5	53	60
Oct 7	8.1	220	11.6	7.5	55	64
Oct 14	8.0	193	12.4	6.5	115	90
Oct 21	7.8	223	12.2	5.0	41	34

Continued

Table 5. Concluded.

Date	pH (units)	Conductivity (µmhos/cm)	Dissolved Oxygen (mg/L)	Temperature (°C)	Suspended Sediments (mg/L)	Turbidity (FTU)
			1980			
April 16	7.6	195	13.7	<1.0	17	9
May 10	7.9	223	12.4	10.0	186	115
May 18	7.3	198	11.0	12.5	103	45
May 25	7.9	214	9.6	13.5	59	31
June 1	7.3	228	10.0	10.0	69	35
June 8	7.5	189	9.8	13.0	786	50
June 15	-	260	9.6	16.0	331	142
June 22	8.2	128	7.9	18.0	1070	420
June 29	8.4	115	8.4	20.0	477	199
July 29	7.7	220	9.2	19.0	149	91
August 7	7.8	217	9.2	19.0	80	50
Mean-all samples	7.8	203	10.4	9.5	322	140
Range-all samples	7.3-8.4	115-261	7.9-13.7	0.0-21.0	17-2000	9-845

3. Dissolved Oxygen:

Oxygen concentrations in the Delta channels were consistently high, ranging from 7.9 to 13.7 mg/L and averaging 10.4 mg/L. The lowest values were recorded during periods of high water temperatures during the summer (e.g. 7.9 mg/L at 18.0°C on June 22, 1980). There appears to be little oxygen depression under winter ice - the 10.5 mg/L recorded in late winter (March 12) 1979 is still approximately 72% of saturation at 0°C. This can be ascribed to the low natural productivity of the river, the absence of extraneous sources of organic materials (such as sewage effluents from large towns) and reoxygenation at the falls and rapids in the vicinity of Fort Smith.

4. Temperature:

Recorded water temperatures ranged from 0.0°C, the temperature during most of the period of ice cover, to 21.0°C on July 8, 1979. The period of highest temperatures appears to be from mid-June to mid-August when temperatures exceeding 15°C are common.

5. Suspended Sediments:

Waters in Slave Delta river channels carry relatively high suspended sediments loads during the open water season, especially during the period of highest discharge in June and early July.

The recorded maxima were 2000 mg/L (June 10) in 1979 and 1070 (June 22) in 1980. Under cover of ice, suspended sediment loads decline markedly to values less than 20 mg/L, only 1% of the recorded maximum.

6. Turbidity:

As expected, seasonal variations in turbidity are similar to those for suspended sediment concentrations, highest (to 845 FTU) during freshets and lowest (to 9 FTU) during the winter period of ice cover.

B. Chemical Parameters

1. Major Ions:

Concentrations of major ions in samples of water taken from Slave Delta channels in 1979 and 1980 are presented in Table 6. The water is of the calcium carbonate type with lower proportions of sodium chloride and sulphate. There are insufficient data to make any very meaningful comparisons between years but it does appear that, in June, waters tended to be more dilute in 1980 than in 1979 with lower concentrations of both Ca and HCO_3, the two major constituents. This is borne out by comparisons of conductivity which averaged 243 μmhos in 1979 but only 184 μmhos in 1980 (data from Table 5).

Table 6. Variation in concentrations (mg/L) of major ions in waters of Slave Delta channels, June 3, 1979 to August 7, 1980.

Date	Ca	Mg	Na	K	SO_4	Cl	HCO_3
			1979				
June 3	35	5.9	6.8	2.5	22	7	132
June 10	37	6.5	6.8	2.3	29	7	139
June 17	34	6.5	5.7	1.0	23	6	130
June 24	33	6.4	5.9	1.6	20	6	122
July 1	36	6.4	6.1	1.6	18	6	137
July 8	33	6.2	5.9	1.4	20	7	129
August 21	35	6.3	7.1	1.3	18	5	105
August 29	38	4.9	6.1	1.3	15	7	83
Sept 23	31	5.5	8.1	1.2	15	9	98
Sept 30	30	5.4	7.9	1.2	18	11	90
Oct 7	29	5.5	8.9	1.2	18	14	95
Oct 14	24	5.6	7.5	1.0	16	8	81
Oct 21	28	6.3	9.4	1.1	18	10	97
			1980				
April 16	38	2.0	8.7	1.1	15	12	92
May 10	26	5.8	10.0	1.4	15	9	84

Continued

Table 6. Concluded

Date	Ca	Mg	Na	K	SO_4	Cl	HCO_3
May 18	23	5.6	8.2	1.2	13	8	74
May 25	25	6.0	9.6	1.2	14	10	82
June 1	25	6.3	9.8	1.2	18	9	85
June 8	22	5.1	7.8	0.9	16	7	73
June 22	15	4.2	5.1	0.7	11	4	51
June 29	15	3.1	3.2	0.6	10	3	53
July 29	34	8.8	8.5	1.4	18	10	95
August 7	33	7.8	8.5	0.6	23	13	94
Means 1979	32.5	5.9	7.1	1.5	19.2	7.9	111
1980	25.6	5.5	7.9	1.0	15.3	8.5	78
Overall	29.5	5.7	7.5	1.3	17.5	8.2	97
Range 1979	24-38	4.9-6.5	5.7- 9.4	1.0-2.5	15-29	5-14	81-139
1980	15-38	2.0-8.8	3.2-10.0	0.6-1.4	10-23	3-13	51- 95
Overall	15-38	2.0-8.8	3.2-10.0	0.6-2.5	10-29	3-14	51-139

Table 7. Concentrations (mg/L) of selected macronutrients in water samples from Slave Delta channels, 1979. Data for total dissolved nitrogen (TDN), total dissolved phosphorus (TDP) and, reactive silica (SiO_2).

Date	TDN	TDP	SiO_2
June 3	0.49	0.23	2.32
June 10	0.59	0.28	2.82
June 17	0.57	0.28	1.81
June 24	0.47	0.13	1.43
July 1	0.46	0.35	1.97
July 8	0.53	0.21	1.22
August 21	0.81	0.05	2.39
August 29	1.02	0.02	1.32
Sept 23	0.63	0.11	0.61
Sept 30	0.54	0.03	0.40
October 7	0.62	0.07	0.36
October 14	0.54	0.03	3.50
October 21	0.51	0.05	3.70
Slave Delta (This study)			
Mean	0.60	0.14	1.83
Range	0.46 - 1.02	0.02 - 0.35	0.36 - 3.70
Athabasca River (McCart et al 1977)			
Mean	0.42	0.04	2.54
Range	0.29 - 0.66	0.0 - 0.16	0.55 - 5.53

2. Macronutrients:

Concentrations of several macronutrients were determined for a series of samples taken from Slave Delta channels in 1979 (Table 7). Mean concentrations of both total dissolved nitrogen (TDN) and total dissolved phosphorus (TDP) are higher than, though still within the range of, those recorded for the Athabasca River while the mean concentration of reactive silica ($SiCO_2$) is lower than that recorded for the Athabasca. As McCart et al. (1977) reported for the Athabasca River, concentrations of TDP tend to be highest during the period of high flows in June and July while concentrations of reactive silica are generally higher in the fall than in summer. TDN concentrations peaked in August but were otherwise similar throughout the sampling period.

Chapter V

MACROINVERTEBRATE STUDY RESULTS

A. Benthic Invertebrates in Major Channels

The species composition and density (No. organisms/m^2) of benthic macroinvertebrates at various depths in the Slave River Delta are presented in Table 8 for a fall (1978) and spring (1980) sampling period. Table 9 summarizes the relative abundance of each major taxonomic group. The data show that, together, oligochaetes (aquatic worms) and chironomid (non-biting midge) larvae best typify the aquatic invertebrate fauna of the Slave River Delta, representing 93% of all invertebrates sampled during the fall, and 66% of all invertebrates sampled during the spring.

Ignoring any possible year to year variations, the most significant difference between the fall and spring macroinvertebrates communities of the Slave River Delta was a difference in standing crop. In the fall, for example, there were 4890 organisms/m^2 in water less than 1.0 m deep (where most benthic invertebrate production in the Slave River Delta probably occurs), compared to 1350 organisms/m^2 in the spring. Similar differences were observed offshore in all but the deepest water. Macroinvertebrate densities for all depths combined averaged 1272 organisms/m^2 in the fall and 599 organisms/m^2 in the spring. Other differences included a

Table 8. Species composition and density (No. organisms/m^2) of benthic macroinvertebrates at various depths in the Slave River Delta, Fall 1978 and Spring 1980.

Taxa	<1.0 m		1.0 - 2.9 m		3.0 - 4.9 m		>5.0 m	
	Fall	Spring	Fall	Spring	Fall	Spring	Fall	Spring
Nematoda	17.9	87.1	9.7	21.5	1.8	14.3	1.9	1.4
Cnidaria								
Hydra sp.						1.4		
Oligochaeta	2385.6	252.1	612.1	19.1	38.2	38.7	10.8	23.0
Hirudinea								
Erpobdella punctata		1.0						
Amphipoda								
Gammarus lacustris		1.0						
Hyalella azteca	9.0	7.2	0.6	2.4	3.6			
Ostracoda								
Candona sp.	1.8	183.5	5.1	57.4		21.5		8.6
Ephemeroptera								
Ametropus neavei			2.1		3.6		2.9	
Baetis sp.								1.4
Callibaetis coloradensis	1.8	1.0						
Centroptilium sp.		3.1						
Ephemerella inermis		1.0						
E. moffatae		4.1				2.9		4.3
E. sp.					1.8		3.4	
Heptagenia sp.		5.1		2.4			1.9	
Hexagenia sp.		1.0						
Paraleptophlebia sp.	1.8							
Siphlonurus sp.		37.9		4.8				
Plecoptera								
Isoperla sp.		12.3			1.8	1.4	2.4	5.7

Continued

Table 8. Continued.

Taxa	<1.0 m		1.0 - 2.9 m		3.0 - 4.9 m		≥5.0 m	
	Fall	Spring	Fall	Spring	Fall	Spring	Fall	Spring
Trichoptera								
Agrypnia sp.		1.0						
Brachycentrus sp.			1.9		3.6		1.6	
Hydropsyche separata		2.0	0.6		21.5	10.0	15.6	
Mystacides sp.	1.8							
Neureclipsis bimaculata			11.4	4.8	30.5	7.2	9.3	
Heteroptera								
Callicorixa audeni	9.0		11.4		3.4		1.0	
Sigara fallenoidea	5.4				1.8			
S. lineata	1.8							
S. trilineata	7.2	1.0						
Coleoptera								
Hydroporus		1.0						
Diptera								
Bezzia/Palpomyia gp. sp.	16.1	30.7	14.1	14.3	3.6	10.0	1.0	1.4
Brillia sp.			2.5				0.5	
Chironomini spp.		23.6		4.8		4.3		
Chironomus spp.	2095.0	29.7	59.3		144.3	2.9	2.6	1.4
Chrysops sp.		4.1			1.8			
Cladotanytarsus		6.1						
Cricotopus sp. 1	7.2	16.4						
C. sp. 2		1.0						
Cryptochironomus sp.	86.1	1.0	16.9		30.3	8.6	5.3	5.7
Cryptotendipes sp. 1		18.4	0.6	14.3	1.8			
C. sp. 2		1.0						
Dicrotendipes sp. 1		0.1					1.1	
D. sp. 2		25.6						
Empididae sp.						1.4		
Eukiefferiella sp.								1.4
Harnischia sp.		6.1				5.7		1.4
Hexatoma sp.	9.0	2.0	1.3		1.8			

Continued

Table 8. Concluded.

Taxa	<1.0 m		1.0 - 2.9 m		3.0 - 4.9 m		>5.0 m	
	Fall	Spring	Fall	Spring	Fall	Spring	Fall	Spring
Larsia sp.	1.8	13.3					1.1	
Monodiamesa sp.	16.1	16.4	19.7	12.0	12.6	11.4	0.5	31.6
Orthocladiinae sp.		1.0		2.4		1.4		
Paracladopelma sp.		5.1	0.6				2.4	
Phaenopsectra sp.		8.2	3.5					
Polypedilum (Polypedilum) sp.	1.8	400.8	0.6	2.4	1.8	5.7		4.3
Potthastia sp.			1.4		1.8			
Procladius sp.	91.5	15.4	71.4	26.3	182.9	44.5	12.2	58.8
Psectrocladius sp.	1.8	13.3						
Rheocricotopus sp.	1.8							
Stictochironomus sp.	16.1	19.5	8.4		32.8	2.7	3.9	7.2
Tanypodinae sp.				2.4		1.4		1.4
Tanytarsini sp.		3.1						8.6
Tanytarsus sp.		9.2		12.0		4.3		2.7
Tipula sp.			2.1					
Trissopelopia? sp.		4.1						
Hydracarina								
Hydrachna sp.		1.0						
Gastropoda								
Hydrobiidae sp.	82.5	55.3	64.9	7.2	17.9	2.9		5.7
Lymnaea sp.	1.8		1.3					
Physa sp.		2.0	2.1			1.4		
Valvata sincera			0.6					
V. tricarinata	12.6	4.1	3.2	4.8			3.5	1.4
Pelecypoda								
Pisidium sp.	3.6	2.0	1.4				2.7	
Total No. of Taxa	28	50	29	18	24	23	22	20
Total No. of Organisms	2726	1317	761	90	330	144	133	124
Total No. of Organisms/m²	4890	1350	931	215	548	206	88	177
Total No. of Ekmans taken	24	42	18	18	21	30	12	30
Total No. of Ponars taken	0	0	12	0	3	0	26	0

Table 9. Per cent composition of major benthic taxa collected at various depths in the Slave River Delta during Fall, 1978 and Spring, 1980.

Taxa	<1.0 m		1.0 - 2.9 m		3.0 - 4.9 m		>5.0 m		All Depths	
	Fall	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall	Spring
Nematoda	0.9	6.4	1.0	10.0	0.3	6.9	2.2	0.8	0.5	6.3
Oligochaeta	48.8	18.7	65.8	8.9	7.0	18.8	12.3	12.9	47.1	17.7
Amphipoda	0.2	0.6	0.1	1.1	0.7	-	-	-	0.2	0.6
Ostracoda	<0.1	13.6	0.5	26.7	-	10.4	-	4.8	0.2	13.4
Ephemeroptera	0.1	4.0	0.2	3.3	1.0	1.4	9.4	3.2	0.4	3.8
Plecoptera	-	0.9	-	-	0.3	0.7	2.7	3.2	0.1	1.0
Trichoptera	<0.1	0.2	1.5	2.2	10.2	8.3	30.2	-	1.4	1.0
Heteroptera	0.4	0.1	1.2	-	0.9	-	1.1	-	0.6	0.1
Chironomidae	47.0	47.7	20.1	35.6	74.7	45.3	34.0	70.0	45.6	48.2
Other Diptera	0.5	2.6	1.8	6.7	1.3	5.6	1.1	0.8	0.7	3.1
Mollusca	2.1	4.6	7.9	5.5	3.3	2.1	7.1	4.0	3.1	4.4
Other Organisms	<0.1	0.8	-	-	0.6	0.7	-	-	0.1	0.8

greater taxonomic diversity in the spring (56 taxa versus 45 taxa) and a more even distribution of numbers between taxa.

During the fall, the total number of organisms declined sharply with depth, from 4890 organisms/m^2 in water less than one metre deep to 88 organisms/m^2 in water over five metres deep (Table 8). Most of this decline was due to a decline in the number of oligochaetes and *Chironomus* sp. which together represented 92% of the organisms in shallow water but only 15% of the organisms in deep water. To a certain degree, the reduction in numbers in deeper water was related to a higher incidence of sandy substrates, an unsuitable habitat for burrowing forms (Cordone and Kelley 1961). As shown in Table 10, samples taken in sandy substrates in the Delta averaged only two taxa and three organisms with six taxa and 20 organisms in samples from silty substrates.

During spring, benthic macroinvertebrate densities in major channels also declined with increasing depth, from 1350 organisms/m^2 in water less than one metre deep to 177 organisms/m^2 in water over five metres deep. Like the fall samples, the decrease was also largely due to a sharp decrease in the number of oligochaetes and chironomids in deeper water.

Table 10. A comparison of the mean number of taxa and mean number of organisms at various depths in sand and silt substrates in the Slave River Delta.

	Silt Substrate			Sand Substrate		
Depth (m)	$\bar{x}$ No. of Taxa (range)	$\bar{x}$ No. of Organisms (range)	No. of Stations	$\bar{x}$ No. of Taxa (range)	$\bar{x}$ No. of Organisms (range)	No. of Stations
0.0-0.9	10.0 (5-15)	326.2 (23-812)	9	-	-	-
1.0-1.9	10.2 (3-19)	241.7 (3-518)	6	-	-	-
2.0-2.9	9.5 (5-21)	40.0 (7- 95)	4	1.0 (1-1)	1.5 (1-2)	2
3.0-4.9	7.5 (3-13)	54.0 (15-104)	6	1.0 (0-2)	2.0 (0-4)	2
>5.0	7.0 (3- 9)	21.6 (5- 36)	5	1.9 (0-5)	2.5 (0-7)	8

In spring the dominant taxa were larvae of the chironomid *Polypedilum* sp., oligochaetes, and ostracods (*Candona* sp.). Of secondary importance were nematodes (roundworms), larvae of *Procladus* sp., *Monodiamesa* sp., *Chironomus* sp., *Cryptotendipes* sp., and *Stictochironomus* sp. (chironomids), *Bezzia/Palpomyia* gp. sp. (biting midges or "no-see-ums"), and hydrobiid snails (tentatively identified as *Amnicola limosa* although *Probythinella lacustris* may also be present). In the fall collections, larvae of *Chironomus* sp. and oligochaetes were the dominant taxa. Sub-dominant taxa were *Procladius* sp., *Crytochironomus* sp., *Stictochironomus* sp., *Monodiamesa* sp., *Bezzia/Palpomyia* gp. sp., and hydrobiid snails.

Ostracods (*Candora* sp.) and nematodes were both a negligible component of the benthos during the fall, but were fairly abundant during the spring, especially in shallow water. Although both are generally a very minor part of the diet of older fish, ostracods in particular are sometimes extensively preyed on by young-of-the-year fish. Chironomids, another important food item, were dominated by *Chironomus* sp. in shallow water during the fall, and by *Polypedilum* sp. during the spring. *Procladius* sp. remained the dominant chironomid in deeper water (>1.0 m) in both seasons.

In both fall and spring, mayfly nymphs (especially *Ephemerella moffatae*), stonefly nymphs (*Isoperla* sp.), and caddisfly larvae (mostly *Hydropsyche separata* and *Neureclipsis bimaculata*) became more important at depths greater than three metres. *Heptagenia* sp. and *Siplonurus* sp. were the most common mayflies found in shallow water. The mayfly *Ametropus neavei*, which was fairly common in the fall collections, was not collected in the spring. Nymphs of this species are found in firm, clean, slightly silty sand in large rivers with a relatively strong current (Edmunds et al. 1976). In the Slave Delta they were only found in deeper water. *Ephemerella moffatae* is a recently described species (Allen 1977) which, until now, has only been recorded from its type locality in the Athabasca River at the junction with the Calling River. *Hydropsyche separata* prefers or requires water that is very turbid (Smith 1979).

B. Benthic Invertebrates in Minor Channels

During the fall, the benthos of major and minor channels was very different. In minor channels, those with a maximum depth seldom over 2.0 m, oligochaetes and the chironomid larvae *Chironomus* sp. and *Procladius* sp. still dominate the macroinvertebrate fauna, but not to the same degree as in larger channels (Table 11). Unlike the larger channels, other chironomid larvae (*Cladotanytarsus* sp., *Pagastiella* sp., *Tanytarsus* sp.) "no-see-um" larvae (*Bezzia* Gp. sp.), daphnia (*Daphnia pulex*) and fingernail clam (*Pisidium* sp. were also important. Total benthic standing crop (4995 organisms/m^2) was

Table 11. Benthic macroinvertebrates in minor channels of the Slave River Delta, Fall, 1978.

Taxa	Total	Per Cent
Oligochaeta	196	18.7
Hirudinea		
Helobdella stagnalis	4	0.4
Pelecypoda		
Pisidium sp.	62	5.9
Sphaerium sp.	1	0.1
Amphipoda		
Gammarus lacustris	2	0.2
Hyalella azteca	21	2.0
Cladocera		
Daphnia pulex	89	8.5
Ostracoda		
Candona sp.	1	0.1
Copepoda	3	0.3
Ephemeroptera		
Callibaetis sp.	1	0.1
Trichoptera		
Agrypnia sp.	2	0.2
Ptilostomis sp.	1	0.1
Diptera		
Bezzia gp. sp.	36	3.4
Chaoborus sp.	1	0.1
Chironomus sp.	193	18.4
Cladotanytarsus sp.	29	2.8
Cryptochirinomus sp.	9	0.9
Cryptotendipes sp.	8	0.8
Heterotrissocladius sp.	1	0.1
Microtendipes sp.	1	0.1
Monodiamesa sp.	1	0.1
Pagastiella sp.	64	6.1
Procladius sp.	203	19.4
Psectrocladius sp.	20	1.9
Stictochironomus sp.	4	0.4
Tanytarsus sp.	96	9.2

Continued

Table 11. Concluded.

Taxa	Total	Per Cent
Total Number of Taxa	26	
Total Number of Organisms	1049	
Total Number of Organisms/m^2	4995	
Total Number of Eckmans	9	

similar to benthic standing crop in the most productive areas of major channels (4890 organisms/m^2).

C. Benthic Invertebrates in Nearshore Areas

Sweep collections at various minnow seining sites in the Slave River Delta were dominated by four groups, including oligochaetes, corixid nymphs and adults, chironomid larvae, and snails. Together these groups accounted for over 90% of the total organisms collected at all the seining sites (Table 12). Dominant taxa were the oligochaetes; the corixids *Trichocorixa borealis*, various *Sigara* species (*S. fallenoidea, S. grossolineata, S. lineata,* and *S. trilineata*) and *Cenocorixa dakotensis*; the chironomids *Chironomus* spp., *Cricotopus* sp., and *Procladius* sp.; the dipteran *Bezzia/ Palpomyia* gp. sp.; and the snails *Amnicola limosa* (possibly also *Probythinella lacustris*), *Lymnaea* sp., and *Valvata tricarinata*.

Steepness (depth) of the seining sites did not appear to be a significant factor in the distirbution of the organisms. Approximately the same number of organisms and taxa were collected in well-vegetated sites with a gentle drop-off or a steep drop-off. The numbers of snails were greater in deep, well-vegetated sites, while the numbers of chironomids were higher in shallow, well-vegetated sites.

Table 12. Mean numbers of macroinvertebrates collected in two net sweeps at various types of seining sites in the Slave River Delta, August 1980.

Taxa	Site Type			
	Shallow, Vegetated	Deep, Vegetated	Shallow, Unvegetated	Deep, Unvegetated
Nematoda	6.8± 3.1	1.0± 0.0	1.0± 0.5	
Oligochaeta	163.8±92.6	147.7±138.8	61.8± 37.4	18.5±18.5
Hirudinea				
Erpobdella punctata	0.1± 0.1			0.5± 0.5
Helobdella stagnalis	0.5± 0.3			
Theromyzon rude	0.2± 0.2	1.3± 1.3		
Amphipoda				
Gammarus lacustris	10.8± 9.4			
Hyalella azteca	1.8± 0.9	3.3± 0.9	0.1± 0.1	
Cladocera				
Daphnia sp.	0.2± 0.2		0.1± 0.1	
Ostracoda				
Candona sp.	1.1± 0.8		1.2± 1.1	
Ephemeroptera				
Baetis sp.	1.4± 1.2			
Callibaetis sp.	0.8± 0.8	0.3± 0.3		
Heptagenia sp.	0.1± 0.1	2.0± 1.0		0.5± 0.5
Hexagenia sp.	0.1± 0.1			
Siphlonurus sp.	1.6± 1.3			
Plecoptera				
Isoperla sp.			0.1± 0.1	
Trichoptera				
Agrypnia sp.	0.1± 0.1			
Hydropsyche sp.				0.5± 0.5

Continued

Table 12. Continued.

Taxa	Site Type Shallow, Vegetated	Deep, Vegetated	Shallow, Unvegetated	Deep, Unvegetated
Neureclipsis				0.5± 0.5
Ptilostomis sp.	1.0± 1.0			
Phryganeidae sp.			0.1± 0.1	
Heteroptera				
Corixidae (imm.) spp.	55.1± 9.9	13.3± 4.7	51.0± 32.7	19.5± 5.5
Cenocorixa dakotensis	2.8± 1.1	1.0± 0.6		3.5± 0.5
Sigara fallenoidea	5.0± 4.0	1.3± 1.3	0.1± 0.1	0.5± 0.5
S. grossolineata	1.4± 1.0		0.4± 0.3	0.5± 0.5
S. lineata	0.1± 0.1	1.7± 1.7	1.9± 1.1	
S. trilineata	1.1± 0.5		0.5± 0.3	1.0± 1.0
Trichocorixa borealis	11.4± 6.0	1.3± 0.9	0.7± 0.4	7.0± 7.0
Gerris sp.	0.4± 0.4	0.3± 0.3	0.2± 0.2	
Lepidoptera	0.1± 0.1			
Coleoptera				
Dytiscidae sp.	0.1± 0.1			
Gyrinus sp.	0.6± 0.4	0.7± 0.7		
Hydroporus sp.	0.1± 0.1			
Diptera				
Bezzia/Palpomyia gp. sp.	24.9±22.1	1.3± 0.3	9.3± 4.6	1.5± 1.5
Brillia sp.				0.5± 0.5
Chironomini spp.	0.4± 0.3		0.2± 0.2	0.5± 0.5
Chironomus spp.	52.1±40.5		138.2±123.8	8.0± 7.0
Chrysops sp.	0.2± 0.2	0.7± 0.7	0.2± 0.2	0.5± 0.5
Cladotanytarsus sp.			2.0± 1.8	

Continued

Table 12. Continued

Taxa	Site Type Shallow, Vegetated	 Deep, Vegetated	 Shallow, Unvegetated	 Deep, Unvegetated
Cricotopus sp.	11.6± 5.1	3.0± 2.0	0.5± 0.5	1.0± 1.0
Cryptochironomus sp.	1.4± 0.6	0.7± 0.7	0.2± 0.2	
Cryptotendipes sp. 1	1.2± 0.7		1.0± 0.9	
C. sp. 2	0.8± 0.3			
Demicryptochironomus sp.	0.1± 0.1			
Dolichopodidae sp.			0.1± 0.1	
Harnischia sp.	0.2± 0.2			
Monodiamesa sp.	0.1± 0.1		0.1± 0.1	
Orthocladiinae sp.	0.1± 0.1			0.5± 0.5
Phaenopsectra sp.	0.1± 0.1			
Polypedilum (Polypedilum) sp.	0.5± 0.3	2.0± 0.6	0.3± 0.3	1.0± 1.0
Potthastia sp.	0.1± 0.1			
Procladius sp.	22.1± 9.6	2.3± 2.3	9.9± 7.9	1.0± 1.0
Psectrocladius sp.	1.4± 0.8	0.7± 0.7	0.3± 0.2	1.0± 1.0
Stictochironomus sp.	0.5± 0.3		0.6± 0.5	
Tanytarsini sp.	0.1± 0.1			
Tanytarsus sp.	0.5± 0.3		0.1± 0.1	
Thienemanniella		1.3± 0.9		
Gastropoda				
Gyraulus spp.	0.1± 0.1	69.3± 53.7		
Helisoma sp.	0.1± 0.1	0.3± 0.3		
Hydrobiidae sp.	45.0±21.1	96.3± 76.9	7.7± 3.2	8.0± 8.0
Lymnaea sp.	12.6± 5.4	103.0± 37.8	0.1± 0.1	5.0± 4.0
Physa sp.	3.6± 1.5	2.3± 1.2	0.1± 0.1	1.0± 1.0
Valvata tricarinata	48.8±30.9	17.3± 13.9	1.2± 0.6	1.5± 1.5

Continued

Table 12. Concluded.

Taxa	Site Type Shallow, Vegetated	 Deep, Vegetated	 Shallow, Unvegetated	 Deep, Unvegetated
Pelecypoda				
Pisidium sp.	0.5± 0.3		0.2± 0.2	
Sphaerium sp.	0.1± 0.1			
No. Sites	8	3	13	2
No. Organisms	3985	1428	3787	167
No. Organisms/Site (±1SE)	498.1±178.8	476.0±103.8	291.3±137.5	83.5±39.5
Total No. Taxa	56	27	34	25

The amount of vegetation did appear to be of significance. Considerably more organisms and taxa were collected at well-vegetated sites (498 organisms and 21 taxa and 476 organisms and 17 taxa per station for shallow and deep sites respectively) than at sites with little or no vegetation (291 organisms and 9 taxa at shallow sites and 83 organisms and 14 taxa at deep sites).

Oligochaetes were abundant at all the stations, but most abundant at shallow, vegetated sites. The numbers of corixids were highest at shallow sites with at least some vegetation. They formed a more dominant part of the community structure at shallow sites with little vegetation owing to the severe reduction in the number of snails at these sites. The chironomids reached their greatest numbers and diversity at shallow, well-vegetated sites. Their numbers also appeared to be high at shallow, unvegetated stations owing to the large number of *Chironomus* spp. collected at one station.

Vegetation was dominated by the horsetail *Equisetum fluviatile* (particularly in sandy areas) and by various pondweeds including *Potamegeton pectinatus*, *P. gramineus* and *P. richardsonii*. The number of organisms collected and their diversity tended to be highest at areas with a mixture of these species.

Chapter VI

FISH STUDY RESULTS

A. Species Composition and Relative Abundance in Major Channels

A total of 23 fish species representing 13 families were captured during two years of study in the Slave River Delta (Table 13). This does not include a group of small-bodied ciscoes which, to date, we have not definitely identified. These ciscoes, which on first inspection appear to resemble a non-anadromous form of least cisco, *Coregonus sardinella*, have a number of characteristics which also places them with the lake cisco, *C. artedii*. Prepelvic distance, for example, when stepped off with dividers is variable, in some cases falling short of the caudal flexure (*C. sardinella*) and in others falling past the caudal flexure (*C. artedii*).

The above ciscoes also show a distinct biomodality in the length-frequency distribution of mature fish that spawn in the Slave River Delta. The fish forming the smaller of the two modes (130 to 150 mm fork length) are characterized by white pelvic fins while the fish forming the larger (220 to 240 mm fork length) are characterized by black pelvic fins. Three possible explanations for the existence of the two modal groups include:

Table 13. List of scientific names, common names, and four letter codes for fish species collected in the Slave Delta, 1978 to 1980

Family amd Generic Name	Common Name	Code
Petromyzontidae		
Lampetra japonica	Arctic lamprey	ARLP
Salmonidae		
Onchorhynchus keta	chum salmon	CHUM
Coregonidae		
Coregonus clupeaformis	lake whitefish	LKWT
Coregonus artedii	lake cisco	LKCS
Coregonus spp.	ciscoes-black fin	COSP-BF
	ciscoes-white fin	COSP-WF
Prosopium cylindraceum	round whitefish	RDWT
Stenodus leucichthys	inconnu	INCO
Thymallidae		
Thymallus arcticus	Arctic grayling	GRAY
Hiodontidae		
Hiodon alosoides	goldeye	GOLD
Esocidae		
Esox lucius	northern pike	PIKE
Cyprinidae		
Couesius plumbeus	lake chub	LKCB
Platygobio gracilis	flathead chub	FHCB
Notropis atherinoides	emerald shiner	EMSH

Continued

Table 13. Concluded.

Family and Generic Name	Common Mane	Code
Cyprinidae		
Notropis hudsonius	spottail shiner	SPCH
Semotilus margarita	pearl dace	PLDC
Catostomidae		
Catostomus catostomus	longnose sucker	LNSK
Catostomus commersoni	white sucker	WTSK
Gadidae		
Lota lota	burbot	BURB
Gasterosteidae		
Pungitius pungitius	ninespine stickleback	NSST
Percopsidae		
Percopsis omiscomaycus	trout-perch	TRPH
Percidae		
Stizostedion vitreum vitreum	walleye	WALL
Perca flavescens	yellow perch	YWPH
Cottidae		
Cottus cognatus	slimy sculpin	SLSC
Cottus ricei	spoonhead sculpin	SPSC

a) The two groups may represent two strong year classes of the same species separated by one or more weak year classes;

b) The two groups may represent separate stocks occupying different areas within Great Slave Lake, both of which return to the Slave River to spawn;

c) The two groups may represent separate but closely related sibling species.

We have recently initiated studies of the meristic and electrophoretic characteristics of these two forms and the initial results suggest that they do, in fact, constitute distinct populations and possibly distinct species. We intend to inform the Mackenzie Basin Study Board of our findings when they are finalized.

Data summarizing the total catch by species for each type of gear used in the Slave River Delta are presented in Table 14. Of 33,323 fish enumerated during the entire study, the white fin form of cisco was the most common (44.3% of the total catch), followed, in decreasing order, by trout-perch (18.3%), the black fin form of cisco (5.1%), emerald shiners (4.8%), and burbot (4.1%). Goldeye, northern pike, lake chub, flathead chub, longnose sucker,

Table 14. A catch summary for each species taken in the Slave Delta, 1978 to 1980

Species	Gillnetting		Minnow Seine		Beach Seine		Trap		Set Line		Total	
	N	%	N	%	N	%	N	%	N	%	N	%
Arctic lamprey	0	0.0	6	<0.1	0	0.0	0	0.0	0	0.0	6	<0.1
Lake whitefish	196	4.1	231	2.0	1	1.1	7	<0.1	0	0.0	435	1.3
Lake cisco	7	0.1	3	<0.1	0	0.0	0	0.0	0	0.0	10	<0.1
Cisco-black-fin	217	4.5	0	0.0	2	2.3	1479	8.9	0	0.0	1698	5.1
Cisco-white-fin	106	2.2	0	0.0	2	2.3	14651	87.8	0	0.0	14759	44.3
Inconnu	50	1.0	1	<0.1	0	0.0	0	0.0	0	0.0	51	0.2
Arctic grayling	2	<0.1	0	0.0	0	0.0	0	0.0	0	0.0	2	<0.1
Goldeye	881	18.3	72	0.6	27	31.0	14	0.1	0	0.0	994	3.0
Northern pike	960	19.9	200	1.7	9	10.3	81	0.5	0	0.0	1250	3.8
Lake chub	1	<0.1	1282	11.1	1	1.1	0	0.0	0	0.0	1284	3.9
Flathead chub	209	4.3	552	4.8	2	2.3	0	0.0	0	0.0	763	2.3
Emerald shiner	0	0.0	1591	13.8	1	1.1	16	0.1	0	0.0	1608	4.8
Spottail shiner	0	0.0	87	0.8	0	0.0	0	0.0	0	0.0	87	0.3

continued

Table 14. Concluded.

Species	Gillnetting		Minnow Seine		Beach Seine		Trap		Set Line		Total	
	N	%	N	%	N	%	N	%	N	%	N	%
Pearl dace	0	0.0	200	1.7	0	0.0	0	0.0	0	0.0	200	0.6
Longnose sucker	564	11.7	511	4.4	10	11.5	6	<0.1	0	0.0	1091	3.3
White sucker	8	0.2	4	<0.1	1	1.1	1	<0.1	0	0.0	14	<0.1
Burbot	728	15.1	340	2.9	22	25.3	104	0.6	172	97.7	1366	4.1
Ninespine stickleback	0	0.0	16	0.1	0	0.0	1	<0.1	0	0.0	17	<0.1
Trout-perch	5	0.1	5774	50.0	1	1.1	327	2.0	0	0.0	6107	18.3
Walleye	891	18.5	6	<0.1	8	9.2	8	<0.1	4	2.3	917	2.8
Yellow perch	1	<0.1	86	0.7	0	0.0	0	0.0	0	0.0	86	0.3
Slimy sculpin	0	0.0	8	<0.1	0	0.0	0	0.0	0	0.0	8	<0.1
Spoonhead sculpin	0	0.0	569	4.9	0	0.0	0	0.0	0	0.0	569	1.7
Total	4826		11539		87		16695		176		33323	

and walleye each accounted for 2.3 to 3.9% of the total catch. The remaining 12 species together represented only 4.3% of the total catch.

The white and black fin form of cisco dominated the overall catch because of the large numbers taken in fish traps during their spawning runs in the fall of 1978. At other times of the year, and in different types of gear, they were relatively rare. Five species, including goldeye, northern pike, longnose sucker, burbot, and walleye together dominate the gillnet and beach seine catches, and therefore more accurately typify the large fish fauna of the Slave River Delta. In minnow seines, trout-perch (50.0% of the total catch), emerald shiner (13.8%), and lake chub (11.1%) were the most frequently taken species in both 1979 and 1980, followed by what were mainly young-of-the-year and yearling flathead chub (4.8%) and longnose sucker (4.4%). Lake whitefish and spoonhead sculpin young-of-the-year, relatively rare in 1979 (0.3 and 0.8% of the total minnow seine catch respectively), were much more common in 1980 (3.0 and 7.5%). Pike and burbot showed the opposite pattern, relatively common in 1979 (2.6 and 5.8% of the total minnow seine catch respectively) but uncommon in 1980 (both 1.2%).

B. Catch Per Unit Effort and Distribution

Table 15 summarizes the seasonal variation in total gillnet catch per unit effort (hrs) for each major channel in the Slave River Delta. The data show that, while the relative abundance of fish may differ significantly from one channel to another, increases or decreases in the number of fish in each channel generally follow the same pattern from one season to another.

Differences between the same season from year to year are more significant. Total catch per unit effort in the fall of 1978 (0.19 fish per gillnet hour) was, for example, considerably lower than in the fall of 1979 (0.40 fish per gillnet hour), because of, first, a proportionately greater sampling effort in unproductive areas in 1978, and second, a shorter sampling period in 1979 that more closely coincided with the periods of major fish movements. Catch per unit effort in the spring of 1980 (0.28 fish per gillnet hour) was higher than in 1979 (0.08 fish per gillnet hour) because of an earlier spring breakup in 1980 that allowed the field crews to more effectively sample the upstream migrations of spring spawning fish species. Catches during the summer were similar in both 1979 and 1980 (0.16 and 0.18 fish per gillnet hour respectively).

Table 15. Seasonal variations in catches per unit gillnet effort in the major channels of the Slave River Delta, 1978 to 1980.

Time Period	Slave River	Resdelta Channel	East Channel	Middle Channel	Steamboat Channel	Nagle Channel	TOTAL
1978 Fall							
Effort (hrs)	395.5	300.5	232.0	254.0	230.5	144.5	1557.0
No. of fish	112	78	16	37	28	26	297
CPUE	0.28	0.26	0.07	0.15	0.12	0.18	0.19
1979 Spring							
Effort (hrs)	317.0	401.0	332.0	471.0	293.0	287.0	2101.0
No. of fish	41	78	6	11	14	10	160
CPUE	0.13	0.19	0.02	0.02	0.05	0.03	0.08
1979 Summer							
Effort (hrs)	1063.0	789.0	198.0	305.5	223.0	165.0	2743.5
No. of fish	209	190	19	20	7	6	451
CPUE	0.20	0.24	0.10	0.07	0.03	0.04	0.16
1979 Fall							
Effort (hrs)	2767.5	1482.5	94.5	190.0	102.5	103.0	4740.0
No. of fish	1259	605	10	12	8	8	1902
CPUE	0.45	0.41	0.11	0.06	0.08	0.08	0.40
1980 Spring							
Effort (hrs)	3178.5	2558.0	207.0	421.0	210.0	158.0	6732.5
No. of fish	1128	582	32	72	16	29	1859
CPUE	0.35	0.23	0.15	0.17	0.08	0.18	0.28

Continued

Table 15 Concluded.

Time Period	Slave River	Resdelta Channel	East Channel	Middle Channel	Steamboat Channel	Nagle Channel	TOTAL
1980 Summer							
Effort (hrs)	460.0	208.0	52.0	103.5	48.0	49.0	920.5
No. of fish	91	28	14	16	6	10	165
CPUE	0.20	0.13	0.27	0.15	0.13	0.20	0.18
TOTAL							
Effort (hrs)	8181.5	5739.0	1115.5	1745.0	1107.0	906.5	18794.5
No. of fish	2840	1561	97	168	79	89	4834
CPUE	0.35	0.27	0.09	0.10	0.07	0.10	0.26

Catches were, overall, highest during the fall (0.35 fish per gillnet hour for all catches combined) and spring (0.23) study periods when the greatest fish movements occur, and lowest during the summer (0.17) when fish movements are reduced. The total gillnet catch per unit effort for the entire study period averaged 0.26 fish per gillnet hour, or approximately six fish per standard gillnet gang per day.

Fish susceptible to capture in gillnets are, on the average, three to five times more abundant in the Slave River (0.35 fish per gillnet hour) and Resdelta Channel (0.27 fish per gillnet hour) than they are in East, Middle, Steamboat, and Nagle channels (0.07 to 0.10 fish per gillnet hour). A species by species comparison (Table 16) shows that, for some species (lake whitefish, inconnu, the white fin form of cisco, northern pike, longnose sucker, burbot, and walleye) the differences may be even greater. Goldeye on the other hand, tend to be fairly abundant throughout the Delta, while the flathead chub is equally abundant in Resdelta, East, and Middle channels. The black-fin form of cisco, which moves into the Slave Delta River from Great Slave Lake to spawn during late fall, appears to be as abundant in the southern channels of the Delta (Nagle and Steamboat Channels) as it is in the northern channels (Resdelta Channel and the Slave). It is, however, rarely taken in the central portion of the Delta (East and Middle Channels).

Table 16. Gillnet catch per unit effort for each species taken in the Slave Delta River, 1978 to 1980.

	Gillnet CPUE (Hours) x 100					
Species	Slave River	Resdelta Channel	East Channel	Middle Channel	Steamboat Channel	Nagel Channel
Lake whitefish	1.63	1.01	0.00	0.00	0.18	0.22
Lake cisco	0.04	0.05	0.00	0.06	0.00	0.00
Cisco-black fin	1.81	0.59	0.27	0.06	0.90	0.55
Cisco-white fin	1.14	0.21	0.00	0.06	0.00	0.00
Inconnu	0.39	0.26	0.09	0.11	0.00	0.00
Grayling	0.02	0.00	0.00	0.00	0.00	0.00
Goldeye	6.64	3.14	3.41↑	3.50↑	2.26↑	3.75↑
Northern pike	9.35	2.28	0.99	0.46	1.17	3.42
Flathead chub	0.64	1.88	1.97↑	1.15↑	0.45	0.22
Longnose sucker	2.75	5.19	0.54	1.43↑	0.27	0.33
White sucker	0.07	0.02	0.00	0.06	0.00	0.00
Burbot	3.04	7.20	0.54	1.72	0.63	0.11
Trout-perch	0.06	0.00	0.00	0.00	0.00	0.00
Walleye	6.39	5.40	0.90	1.09	1.26	1.21
Yellow perch	0.01	0.00	0.00	0.00	0.00	0.00

The distribution of small fish in the Slave River Delta was quite different from that of larger fish. While East, Middle, Steamboat, and Nagle channels are clearly of less importance than Resdelta Channel and the lower Slave River to large fish other than goldeye and flathead chub, these channels were of major importance as feeding and rearing areas for both the smaller species of fish and young-of-the-year of the larger species. The latter include lake whitefish, northern pike, flathead chub, longnose sucker, and burbot. Total catch per unit effort (metres of shoreline seined x 100) during the entire study period ranged from 0.17 in Nagle Channel to 0.94 in Resdelta Channel (Table 17). Seasonally, catches were always highest during summer and lowest during fall.

The distribution and abundance of 11 fish species taken in minnow seines in the Slave River Delta are summarized in Table 18. Lake whitefish young-of-the-year, goldeye young-of-the-year, flathead chub, and spoonhead sculpin young-of-the-year all had their highest densities in Resdelta Channel or the Slave River, and their lowest densities in Nagle Channel and most of the minor channels. In contrast, young-of-the-year pike and burbot were most abundant in the central portion of the Delta, including East, Middle, and Steamboat Channel as well as most of the smaller, minor channels.

Table 17. Seasonal variations in catches per unit effort (metres of shoreline seined) for minnow seining in the Slave River Delta, 1979 and 1980.

Time Period	Slave River	Resdelta Channel	East Channel	Middle Channel	Steamboat Channel	Nagle Channel	Minor Channels	TOTAL
1979 Spring								
Effort (metres)	860	330	345	1740	645	0	810	4730
Catch	593	108	192	822	332	ND[a]	710	2748
CPUE	0.69	0.33	0.56	0.47	0.51	ND[a]	0.87	0.58
1979 Summer								
Effort (metres)	0	112	225	515	219	115	304	1490
Catch	ND[a]	223	194	265	202	90	254	1228
CPUE	ND[a]	1.99	0.86	0.51	0.92	0.78	0.84	0.82
1979 Fall								
Effort (metres)	0	200	250	600	190	215	0	1455
Catch	ND[a]	61	36	165	100	24	ND[a]	386
CPUE	ND[a]	0.31	0.14	0.27	0.53	0.11	ND[a]	0.27
1980 Spring								
Effort (metres)	1537	1459	1358	3133	1976	455	1542	11460
Catch	1037	442	205	908	534	20	441	3587
CPUE	0.67	0.30	0.15	0.29	0.27	0.04	0.29	0.31
1980 Summer								
Effort (metres)	804	579	450	1101	495	54	528	4011
Catch	424	1693	230	1181	269	11	240	4048
CPUE	0.53	2.92	0.51	1.07	0.54	0.20	0.45	1.01
TOTAL								
Effort (metres)	3201	2680	2628	7089	3525	839	3184	23146
Catch	2054	2527	857	3341	1437	145	1636	11997
CPUE	0.64	0.94	0.33	0.47	0.41	0.17	0.51	0.52

ND[a] - No data.

Table 18. Minnow seine catch per unit effort for 11 species of fish in the Slave River Delta, 1979 and 1980.

	Catch per Metre of Shoreline Seined x 100						
Species	Slave River	Resdelta Channel	East Channel	Middle Channel	Steamboat Channel	Nagle Channel	Minor Channels
Lake whitefish	4.62	0.34	0.80	0.13	1.02	0.00	0.13
Goldeye	0.28	1.38	0.04	0.17	0.28	0.00	0.09
Northern pike	0.44	0.71	0.91	0.92	1.28	0.72	0.82
Lake chub	3.94	5.86	4.83	6.07	3.21	3.22	9.20
Flathead chub	6.03	3.28	1.90	1.28	2.10	0.12	1.63
Emerald Shiner	8.97	11.38	5.56	3.22	11.18	7.03	5.24
Pearl Dace	1.03	0.15	1.45	1.16	0.68	0.12	0.57
Longnose sucker	2.16	2.65	1.90	1.34	1.79	0.24	3.71
Burbot	1.84	0.26	0.15	2.48	1.84	0.12	0.91
Trout-perch	26.05	61.72	13.05	24.36	15.04	4.89	19.60
Spoonhead sculpin	2.81	4.74	0.95	3.26	1.90	0.12	0.88

Trout-perch were, together with emerald shiners and lake chub, the most abundant species overall and their distributions broadly overlapped. Trout-perch, the most abundant species, were most abundant in Resdelta channel and least abundant in Nagle Channel. Lake chub catches were highest in the central portion of the Delta while emerald shiners were most abundant in the outer portions of the Delta, including Resdelta Channel to the north and Steamboat and Nagle Channel to the south.

C. Distribution of Small Fish Among Different Shoreline Types

Each minnow seine site was classified in one of four broad categories:

a) Shallow water areas with a low gradient and largely covered with aquatic vegetation;

b) Shallow water areas with a low gradient and little or no aquatic vegetation;

c) Deep water areas with a steep gradient and bordered with a dense growth of aquatic vegetation along the shoreline;

d) Deep water areas that drop off sharply with little or no vegetation along the shoreline.

Catch per unit effort were calculated to assess the relative importance of these inshore habitat types to fish in the Slave River Delta. Catches which were taken from sites that clearly included more than one of the above shoreline habitat types were not considered, unless the dominant type represented a large fraction (generally more than 90%) of the total shoreline sampled. It was rarely possible, for example, to sample a long stretch of shallow water which had little or no vegetation without sampling at least a short stretch of dense aquatic vegetation as the seine was pulled inshore.

The results are presented by season for each major species in Table 19. The data for all seasons combined show that, overall, fish tend to be at least twice as abundant in shallow, well vegetated areas (88.4 fish per metre of shoreline seined x 100) as they are in the other three habitat types (33.0 to 39.0 fish per metre of shoreline seined x 100). A species by species account shows a similar pattern for lake whitefish young-of-the-year, flathead chub, pearl dace, burbot young-of-the-year, trout-perch, and spoonhead sculpin young-of-the-year. Northern pike and emerald shiners, on the other hand, appear to prefer vegetated areas regardless of depth, while both the young-of-the-year and small juveniles of longnose suckers appear to prefer shallow water, regardless of the presence of vegetation.

Table 19. Seasonal variation in minnow seine catches for 11 species of fish in four different kinds of inshore habitat: shallow, vegetated areas with a low gradient; shallow, unvegetated areas with a low gradient; deep, vegetated areas with a steep gradient; deep, unvegetated area with a steep gradient. An explanation of the codes used for the various species is given in Table 13.

Bank Type	LKWT	GOLD	PIKE	LKCB	FHCB	EMSH	PLDC	LNSK	BURB	TRPH	SPSC	Effort (m.)	Total CPUE X 100
Spring 1979													
Low, vegetated	0.4	0.3	0.3	3.0	4.9	2.3	4.8	4.4	10.8	32.6	1.0	1355	64.8
Low, barren	0.2	0.4	0.2	9.3	5.5	0.9	1.9	5.7	5.0	28.0	0.3	1585	57.4
Steep, vegetated	0.0	0.0	0.3	1.7	6.5	1.6	0.2	0.9	0.0	15.8	1.1	645	28.1
Steep, barren	0.0	0.0	0.9	10.4	11.3	6.1	0.0	0.0	0.0	0.0	0.0	115	28.7
Summer 1979													
Low, vegetated	0.0	0.2	4.5	10.1	4.3	50.2	0.0	0.7	0.0	17.6	0.0	552	87.7
Low, barren	0.0	0.0	4.3	25.4	2.2	50.8	1.6	9.7	0.5	9.2	0.5	185	104.3
Steep, vegetated	0.0	0.0	5.9	14.8	0.0	52.4	1.9	0.3	1.3	4.8	0.0	372	81.5
Steep, barren	0.0	0.0	1.2	13.8	0.8	55.5	0.0	0.4	0.4	12.1	0.4	247	84.6
Fall 1979													
Low, vegetated	0.0	0.0	3.3	0.0	0.0	1.7	0.0	0.0	0.0	0.0	0.0	60	5.0
Low, barren	0.0	0.0	4.4	8.6	0.0	10.8	0.3	0.3	0.0	1.1	0.0	360	25.6
Steep, vegetated	0.0	0.0	4.3	13.2	0.0	14.3	1.8	0.0	0.7	2.3	0.2	440	36.8
Steep, barren	0.0	0.0	1.8	5.5	0.0	4.2	0.8	0.4	0.2	7.5	0.0	505	20.4
Spring 1980													
Low, vegetated	8.9	0.2	1.1	5.6	0.4	13.1	2.3	0.2	4.5	16.1	16.7	1116	69.0
Low, barren	1.3	0.4	0.6	5.8	0.9	3.8	0.5	1.6	0.3	8.6	1.9	7750	25.8
Steep, vegetated	0.2	0.0	1.7	6.1	0.0	5.7	0.0	0.0	0.2	4.0	1.0	522	19.0
Steep, barren	0.6	≈0.0	0.3	2.4	1.0	1.5	0.3	0.2	0.3	6.1	3.1	2072	16.1

(continued)

Table 19. Concluded.

Bank Type	LKWT	GOLD	PIKE	LKCB	FHCB	EMSH	PLDC	LNSK	BURB	TRPH	SPSC	Effort (m.)	Total CPUE X 100
Summer 1980													
Low, vegetated	0.0	0.7	0.4	2.8	3.0	5.6	0.1	2.6	0.1	104.8	3.2	1699	123.2
Low, barren	0.0	0.1	0.1	3.2	3.9	2.2	0.1	3.1	0.0	63.8	4.1	1604	80.4
Steep, vegetated	0.0	0.0	0.3	0.9	0.3	1.2	0.3	0.0	0.0	18.5	0.6	340	22.1
Steep, barren	0.0	1.9	0.5	1.9	3.5	4.3	0.0	1.4	0.0	95.1	3.8	368	112.5
Seasons combined													
Low, vegetated	2.2	0.4	1.0	4.3	3.1	11.5	1.9	2.3	4.1	52.3	5.3	4782	88.4
Low, barren	0.9	0.3	0.6	6.4	1.9	4.2	0.6	2.4	0.9	18.8	1.9	11484	39.0
Steep, vegetated	≈0.0	0.0	2.3	6.9	1.9	13.0	0.7	0.3	0.4	9.2	0.6	2319	35.4
Steep, barren	0.4	0.2	0.7	4.0	1.5	6.4	0.3	0.4	0.3	16.5	2.4	3307	33.0

The distribution of the species discussed above did not always follow the same pattern in every season, partly because different fish were abundant at different times of the year, lake chub, emerald shiners, and burbot young-of-the-year were, for example, far more abundant in 1979 than in 1980. Lake whitefish young-of-the-year, trout-perch, and spoonhead sculpin young-of-the-year were, on the other hand, much more common in 1980.

Changes in the habitat distribution of small fish from one season to the next were, to some extent, a reflection of changes in sampling effort. Shallow water areas were, for instance, the most commonly sampled inshore habitats during spring and summer, but not in the fall because of declining water levels. Since most sampling was also done during the spring when there was still very little aquatic vegetation, areas lacking vegetation ended up with most of the sampling effort. As a result, some species like pike, and emerald shiners appear to favour vegetated shorelines, largely because neither species was as common during the spring as during summer. In fact, when they were common, open shallow water areas were favoured as much as other habitat types.

As described earlier in the macroinvertebrate studies, nearshore habitats in the Slave River Delta are dominated by

Table 20. Per cent occurrence values of food items in stomachs of 12 fish species sampled in the Slave River Delta, 1979 and 1980 samples combined. An explanation of the codes used for the various species is given in Table 13.

Food Item	LKWT*	GOLD*	PIKE*	LKCB	FHCB	EMSH	SPSH	PLDC	LNSK	BURB*	TRPH	SPSC
						Fish Species						
Oligochaeta				3	6				5			
Pelecypoda				3	6				14		5	21
Gastropoda				6	12			10	14		3	4
Cladocera	9			5		4				3		
Amphipoda			26						5	3		
Copepoda	35					4			5	29	5	
Aquatic Insects												
Chironomidae	96	86	12	21	29	16	61	52	62	87	70	96
Ceratopogonidae					12	16	6					
Trichoptera				2	6						3	
Ephemeroptera	13	10	11	2						26	10	8
Plecoptera		5		8	12	4				6		
Corixidae		76	5	43	47	40	50	38	5		3	8
Terrestial Insects												
Diptera	9	5				4						
Hymenoptera						8						
Lepidoptera	4	5										
Homeoptera							6					
Coleoptera			2	2		4						
Fish Eggs									5			17
Fish Remains			38	2								
Invertebrate Remains			6	5	29	8	17	10	5	16	5	
Number of Stomachs	23	21	66	63	17	25	18	21	21	31	40	24

* Young-of-the-year only

Table 21. Summary of fish and invertebrate numbers at each of the four major shoreline habitat types in the Slave River Delta.

	Shoreline Habitat Type			
	Shallow, Vegetated	Shallow, Bare	Deep, Vegetated	Deep, Bare
Overall Fish Catch per Metre of Shoreline Seined (X100)	88.4	39.0	35.4	33.0
Chironomid and Corixid Densities (Mean No./2 Net Sweeps)	170.4	208.6	29.6	45.5
Oligochaete and Snail Densities (Mean No./2 Net Sweeps)	274.0	70.9	436.2	34.0
All Invertebrates (Mean No./2 Net Sweeps)	498.1	291.3	476.0	83.5

oligochaetes, chironomid larvae, corixids, and snails. The stomach contents of 12 species of small fish taken from all habitats in the Delta, however, shows that chironomids and corixids are by far the most important food items eaten, while snails and oligachaetes are rarely consumed (Table 20). A comparison between fish and invertebrate numbers in each of the four nearshore habitat types (Table 21) further suggests that shallow, well vegetated areas are preferred by fish because of an abundance of food and cover. Shallow, poorly vegetated areas have an adequate supply of food but no cover, while deep, vegetated areas have adequate cover but relatively little of the preferred food organisms.

D. Drifting Fry

Catches of recently emerged young-of-the-year in the Slave River are summarized in Figure 3 for drift samples taken June 1 to July 11, 1979. Figure 4 summarizes the results of similar drift samples taken in 1980 from May 10 to June 29.

In 1979, a total of 11 species was taken, including unidentified coregonid fry, an unknown cyprinid (Unknown A) that most resembled lake chub, and an unknown sculpin that was probably a spoonhead sculpin. In 1980, seven species were taken, including the same coregonid fry taken in 1979, and unknown fry,

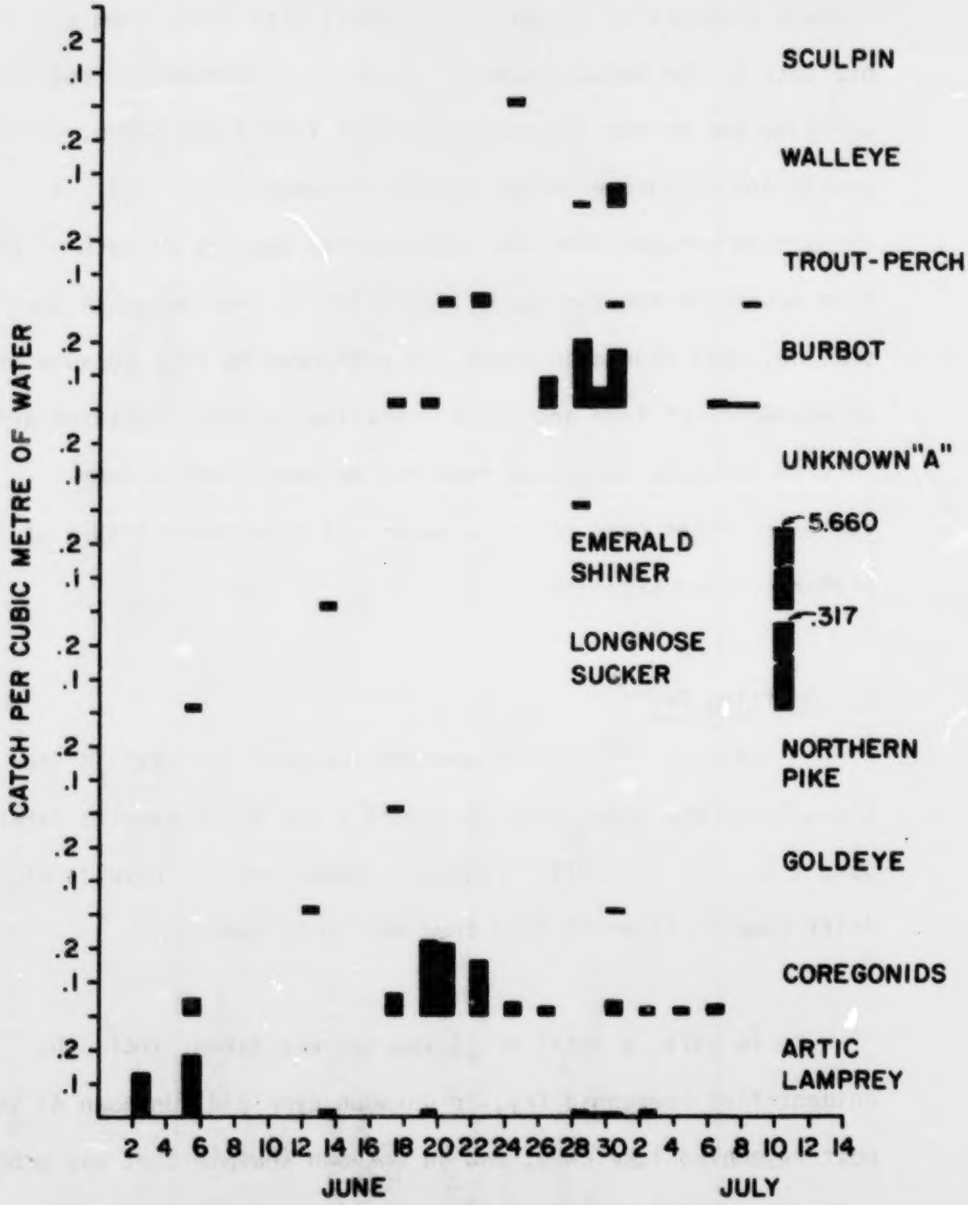

Figure 3. Drift rates for various species of recently emerged young-of-the-year fish in the lower Slave River, June 1 to July 11, 1979.

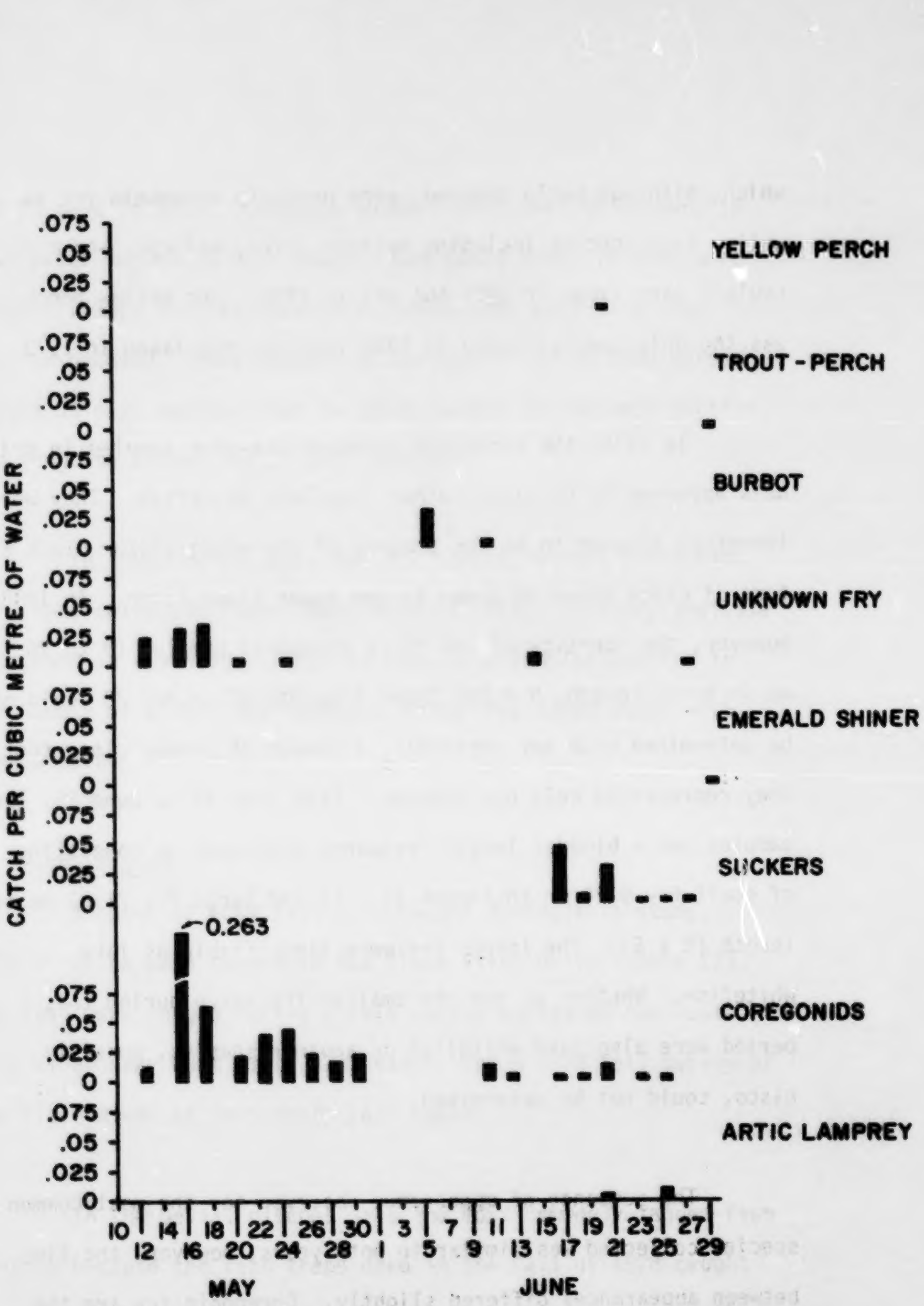

Figure 4. Drift rates for various species of recently emerged young-of-the-year fish in the lower Slave River, May 12 to June 29, 1980

which, although badly damaged, were probably coregonid fry as well. Four species including goldeye, pike, walleye, and a sculpin were taken in 1979 but not in 1980. The yellow perch was the only species taken in 1980 that was not taken in 1979.

In 1979, the coregonid young-of-the-year sampled in drift nets appeared to be cisco rather than lake whitefish. They were therefore assumed to be the progeny of the white and/or black fin form of cisco known to spawn in the lower Slave River. In 1980, however, the identity of the first coregonid samples (9 to 20 mm in total length, N = 55) taken from May 12 to May 30 could not be determined with any certainty, although it seemed clear that they represented only one species. From June 10 to June 25, the samples had a bimodal length-frequency distribution consisting of small fry 9-20 mm in length (N = 6) and large fry 21-33 mm in length (N = 6). The larger fry were identifiable as lake whitefish. Whether or not the smaller fry taken during this period were also lake whitefish or another species, possibly cisco, could not be determined.

The sequence of appearance observed for the most common species collected was similar in both years, however, the time between appearances differed slightly. Coregonid fry are the first to appear followed by burbot after 10 days in 1979 and

and 20 days in 1980. Longnose suckers were next to appear, 10 days after burbot in both years. Emergence times in 1980 were evidently much earlier than 1979, presumably because of the earlier breakup. Peak numbers of coregonid fry in 1980 were caught 35 days earlier than in 1979, burbot fry 23 days earlier, and longnose sucker fry 24 days earlier.

In 1980, drift rates for all species except coregonids were apparently six times lower than in 1979. This may indicate a decline in spawning success in view of a similar decline in the number of burbot and longnose sucker fry taken later with minnow seines (Table 19).

E. Fish Tagging

A total of 4044 fish were tagged during this study, 2639 of which were tagged in the Slave River Delta (Table 22). The rest were tagged during a 1979 spring survey of the lower Salt River near Fort Smith (771 tags), and a 1979 fall survey of the Slave River at Fort Smith (634 tags).

In the Delta, ciscoes were the most commonly tagged fish largely because the fish traps used in the fall of 1978 caught large numbers of cisco, but relatively few individuals of other species. In 1979 and 1980, gillnets were used much more extensively

Table 22. Summary of fish tagged during the present study.

	Slave Delta River Area				Fort Smith Area		
Species	Fall 1978	Spring 1979	Fall 1979	Spring 1980	Spring 1979	Fall 1979	Total
Lake whitefish	5	0	22	26	191	90	334
Lake cisco	0	0	3	0	0	0	3
Cisco (black fin)	849	0	1	0	0	0	850
Inconnu	0	0	14	1	0	3	18
Round whitefish	1	0	0	0	0	0	1
Goldeye	24	3	67	32	13	500	639
Northern pike	81	6	183	193	27	19	509
Flathead chub	0	1	4	11	3	0	19
White sucker	0	0	0	2	4	0	6
Longnose sucker	0	12	144	103	483	15	757
Burbot	173	24	220	60	17	1	495
Walleye	7	5	243	121	31	6	413
TOTAL	1140	51	901	549	769	634	4044

and northern pike, longnose sucker, burbot, and walleye were the most commonly tagged fish. At Fort Smith, lake whitefish and goldeye were the most frequently tagged fish in the Slave River, while lake whitefish and longnose sucker were the most common fish tagged in the Salt River, 29 km downstream of Fort Smith.

As of December 31, 1980, 184 tagged fish had been recovered for a total recapture rate of 4.2% (Table 23). Recapture rates for individual species ranged from highs of 5.3 to 13.8% for lake whitefish (46 recaptures), northern pike (27 recaptures), longnose suckers (55 recaptures), and walleye (33 recaptures), to lows of 0.5 to 1.2% for the black-fin form cisco (9 recaptures), goldeye (3 recaptures), and burbot (6 recaptures). Recapture rates for inconnu (16.7%) and flathead chub (12.5%) were high because, although only two or three fish were recovered, few were marked in the first place.

Of the 184 tag returns, 136 were early recaptures, fish recaptured near the original tagging site within two weeks of being tagged. Of these, 37 were recaptured in the Slave River Delta, 33 by our own field crews, and 4 by the domestic fishery. In the Fort Smith area, 99 fish were recaptured soon after being tagged, 61 by our field crews, and 38 by the domestic fishery. Differences in the recapture rate by domestic fisheries in the

Table 23. Summary of fish tagged and subsequently recaptured as of December 31, 1980. Early recaptures refer to fish that were recaptured near the original tagging site within two weeks of being tagged.

	Delta Area			Fort Smith Area			
Species Tagged	No. Tagged	Early Recaps N (%)	Other Recaps N (%)	No. Tagged	Early Recaps N (%)	Other Recaps N (%)	Total Recaps N (%)
Lake whitefish	53	0 (0.0)	1 (1.9)	281	40 (14.2)	5 (1.8)	46 (13.8)
Lake cisco	3	0 (0.0)	0 (0.0)	0	0 (0.0)	0 (0.0)	0 (0.0)
Cisco (black-fin)	850	8 (0.9)	1 (0.1)	0	0 (0.0)	0 (0.0)	9 (1.1)
Inconnu	15	1 (6.7)	2 (13.3)	3	0 (0.0)	0 (0.0)	3 (16.7)
Round whitefish	1	0 (0.0)	0 (0.0)	0	0 (0.0)	0 (0.0)	0 (0.0)
Goldeye	126	0 (0.0)	0 (0.0)	513	3 (0.6)	0 (0.0)	3 (0.5)
Northern pike	463	12 (2.6)	9 (1.9)	46	3 (6.5)	3 (6.5)	27 (5.3)
Flathead chub	16	1 (6.3)	0 (0.0)	3	1 (33.3)	0 (0.0)	2 (12.5)
White sucker	2	0 (0.0)	0 (0.0)	4	0 (0.0)	0 (0.0)	0 (0.0)
Longnose sucker	259	0 (0.0)	1 (0.4)	498	50 (10.0)	4 (0.8)	55 (7.3)
Burbot	477	5 (1.0)	1 (0.2)	18	0 (0.0)	0 (0.0)	6 (1.2)
Walleye	376	10 (2.7)	14 (3.7)	37	2 (5.4)	7 (18.9)	33 (8.0)
TOTAL	2641	37 (1.4)	29 (1.1)	1403	99 (7.1)	19 (1.3)	184 (4.2)

Delta (0.2%) and the Fort Smith area (2.7%) indicate a substantially greater fishing effort near Fort Smith. Differences between the recapture rate by our own field crews in the two areas (1.2% in the Delta and 4.3% at Fort Smith) also suggests that fish in the vicinity of Fort Smith are not as likely to disperse during early spring or late fall.

The recapture rate for fish recovered at least two weeks after being tagged (N = 48) was 1.1% for fish originally tagged in the Slave River Delta, and 1.3% for fish tagged near Fort Smith. Further details on all tagged fish are given in the life history description of each species.

F. Fish Overwintering

There is little evidence that significant concentrations of fish overwinter in the Slave River Delta. In some years, there is a fairly intense domestic fishery in the Delta during November and December when large numbers of burbot can be taken in nets and on baited set lines. After December, however, catches drop sharply, suggesting that by early January, most fish have left the Delta.

The results of our own late-winter surveys in the Slave River Delta also suggests that few fish use the Delta, at least until April, at which time spring spawning fish species begin to appear, presumably enroute to spawning areas located upstream of the Delta. In 1979, during the period March 12 to March 19, six standard gillnet gangs were fished for a total of 439 hours and captured only one pike. In 1980, April 11 to April 22, six standard gillnet gangs were fished for 888 hours and captured 18 fish, including 1 lake whitefish, 1 goldeye, 1 northern pike, 3 longnose suckers, 1 burbot, and 11 walleye. The lake whitefish and goldeye were immature fish while the burbot was a spent female. The rest, all spring spawning fish, were mostly mature fish approaching spawning. Four of the 11 walleyes taken were, in fact, males in ripe spawning condition.

G. Life Histories of Major Species

Major fish species are considered to be those fish which are susceptible to capture in gillnets and which are generally abundant or economically valuable. In the Slave River Delta, they include lake whitefish, cisco, inconnu, goldeye, northern pike, flathead chub, longnose sucker, burbot, and walleye. The life history of each of these species in the Slave River Delta is described in what follows.

1. **Lake Whitefish:**

The lake whitefish is one of a number of closely related sibling species within the "*Coregonus clupeaformis*" complex (McPhail and Lindsey, 1970). The species complex is widely distributed in Canada and Alaska, absent only from the Atlantic and Pacific coasts, most of the Arctic islands, and parts of the Missouri drainage.

The lake whitefish is the most valuable commercial freshwater fish in Canada. In Great Slave Lake, it forms the basis of an important commercial fishery followed by, in decreasing order of importance, lake trout, inconnu, pike, and walleye. Details of the whitefish fishery in Great Slave Lake are reviewed by Kennedy (1956), Keleher (1972), Bond and Turnbull (1973), Moshenko et al. (1978), and Moshenko and Low (1979).

Over the two years of study, lake whitefish were never abundant in the Slave River Delta, accounting for only 4.1% (N = 196) of the total gillnet catch and 2.0% (N = 231) of the total minnow seine catch. Average catch per gillnet hour (x100) was 1.04, or approximately one lake whitefish per gillnet hour (x100) in Resdelta Channel and the Slave River to 0.20 whitefish per gillnet hour in Steamboat and Nagle Channels. No lake whitefish were ever gillnetted in Middle or East Channel.

Much larger concentrations of lake whitefish are present in the upper Slave River by Fort Smith. From October 1 to October 10, 1979, lake whitefish catches in standard gillnet gangs at Fort Smith averaged 14.7 fish per hour (x100) compared to 0.7 fish per hour (x100) over the same period in the Delta. Domestic catches at Fort Smith were even higher, averaging in excess of 35 whitefish over a 24 hour period with a 12.7 cm stretch mesh gillnet, 23 m in length.

Seasonal variations in gillnet catches of lake whitefish in the Slave River Delta (Figure 5) show two peaks in abundance, the first occurring in late August, 1979, and the second occurring shortly after spring breakup in 1980. Although presumably missed because of a late breakup, a similar peak in abundance probably occurred in the spring of 1979 as well. Small mature fish and juveniles predominated during the early spring peak while large, mature fish predominated in late August. During the fall, lake whitefish catches were low with no evidence of any major upstream or downstream migrations, nor any evidence of spawning activity in the Delta.

The first peak in gillnet catches during early spring is thought to represent a general downstream movement by lake whitefish that stay and overwinter in the upper Slave River after

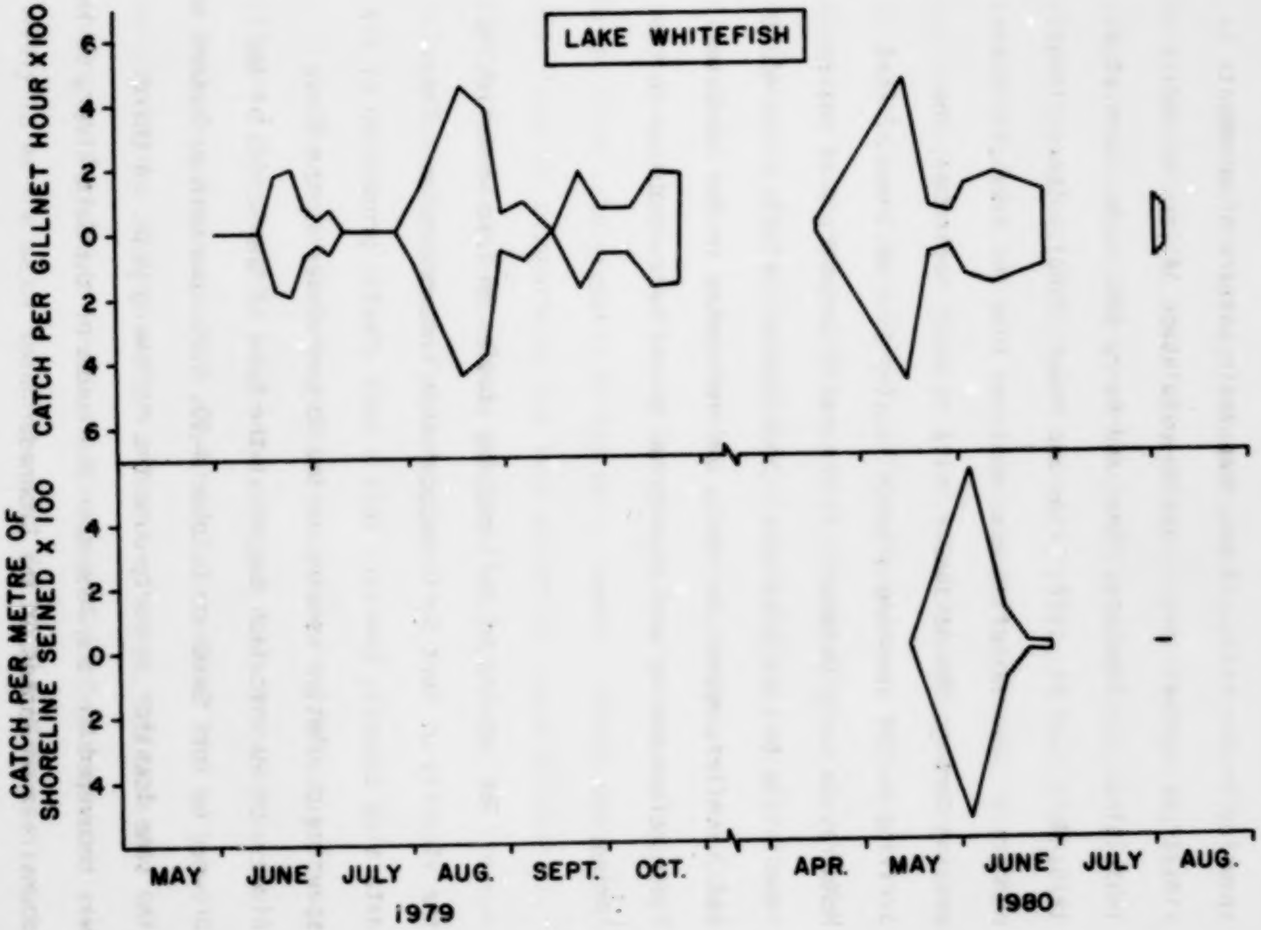

Figure 5. Seasonal patterns of catch per unit effort for lake whitefish taken in gillnets and minnow seines from the Slave River Delta.

spawning in the fall. If so, then their pattern of movements is similar to another river spawning population of lake whitefish inhabiting Lake Athabasca (Bond and Berry 1980 a, b; Jones et al. 1978; McCart et al. 1977; Tripp and McCart 1980). There, large numbers of lake whitefish move upstream into the Athabasca River, passing through the Athabasca Delta in early September, and arriving on the spawning grounds located just upstream of Fort McMurray in early October. At the end of October, most return immediately to Lake Athabasca. Some however, mostly young adults and juveniles, appear to remain and overwinter in the Athabasca River before moving back downstream toward Lake Athabasca in the spring.

The results of fall tagging studies on lake whitefish in the vicinity of Fort Smith support this interpretation. The data also suggest, however, that a much greater proportion of the spawning population remains behind to overwinter in the Slave River. Of 90 whitefish tagged at the base of the Rapids of the Drowned by Fort Smith on October 4-10, 1979, two were recovered in the same location in early June the following year. A third was recovered in late June near the mouth of the Salt River, 30 km downstream of Rapids of the Drowned.

During the spring, lake whitefish appear to be still very abundant in the upper Slave River, further indicating that substantial numbers overwinter there after spawning. Of 191 whitefish tagged in the lower reaches of the Salt River, June 13 to June 17, 1979, 34 were recovered almost immediately, still in the lower reaches of the Salt River. Two, however, were recovered on August 18 and September 9, 1979, by commercial fisherman operating in the Simpson Islands area of Great Slave Lake. This indicates first, that lake whitefish in the upper reaches of the Slave River belong to populations which inhabit Great Slave Lake, and second, that whitefish in the upper Slave River move down to Great Slave Lake probably during early summer. Others may move down later as suggested by one lake whitefish tagged October 22, 1979 in the Slave River Delta and later recaptured in the Simpson Islands area, January or February, 1980.

The second peak in gillnet catches during late August (Figure 5) is thought, though the data are few, to correspond to a gradual upstream spawning migration. Because of the large concentrations of lake whitefish observed there, the base of the rapids located on the Slave River near Fort Smith appears likely to be the major spawning area. In 1979, spawning probably occurred shortly after October 10. Although all of the females sampled were still green at this time, most of the males were ripe (Table 24). Water temperatures were 7.5°C.

Table 24. The spawning condition of lake whitefish taken in the Slave River Delta and the Slave River at Fort Smith, August 22 to November 3, 1979. N = Number of fish, G = green, R = ripe, SO = spawned out.

	MALES				FEMALES				Water Temp.
Date	N	%G	%R	%SO	N	%G	%R	%SO	(°C)
Slave Delta									
Aug. 22	7	100			2	100			15.0
Aug. 29					1	100			12.8
Sept 24	2	100							8.9
Sept 25					1	100			8.3
Oct. 5					1	100			8.0
Oct. 6					1	100			7.5
Oct. 7	1	100							7.5
Oct. 15					1	100			6.5
Oct. 16	1	100			1	100			7.0
Oct. 21	1	100			2	100			5.0
Oct. 22	1	100							5.0
Nov. 3	1	100							1.5
Fort Smith									
Oct. 2	7	42.9	57.1		13	100			ND[a]
Oct. 3	3	33.3	66.6		1	100			ND
Oct. 4	5	20	80		2	100			ND
Oct. 5	8	50	50		8	100			ND
Oct. 6	4	25	75		2	100			ND
Oct. 7	5	20	80		5	100			ND
Oct. 8	7	14.3	85.7		3	100			7.5
Oct. 9	19	15.8	84.2		12	100			7.5

a No Data

Whitefish alevins on the spawning grounds in the upper Slave River probably emerge and drift downstream during spring breakup in response to such cues as increasing photoperiod, water temperature, or turbidity. In 1980, what were probably recently emerged lake whitefish first appeared in drift samples from the Slave River Delta on May 12, shortly after spring breakup. In 1979, breakup in the Delta and lower Slave River was delayed until late May, and recently emerged lake whitefish may have continued on undetected into Great Slave Lake.

Minnow seine catches of lake whitefish in the Slave River Delta were negligible in 1979. They were, however, abundant shortly after spring breakup in 1980, from May 14 to June 20, with a peak on June 3. Few were taken after June 20.

Lake whitefish in the Slave River Delta and the Slave River near Fort Smith ranged from 107 to 503 mm fork length (excluding young-of-the-year), with a peak at 360 to 369 mm fork length (Figure 6). Most (83%) fell in the 310 to 419 mm fork length range. Lake whitefish in the aged sample ranged from 0 to 22 years of age (Table 25) although relatively few fish exceeded 11 years of age, and only one fish exceeded 14 years of age. Both males and females start maturing at age six, reaching complete maturity at age 10 or 11. A comparison of the growth

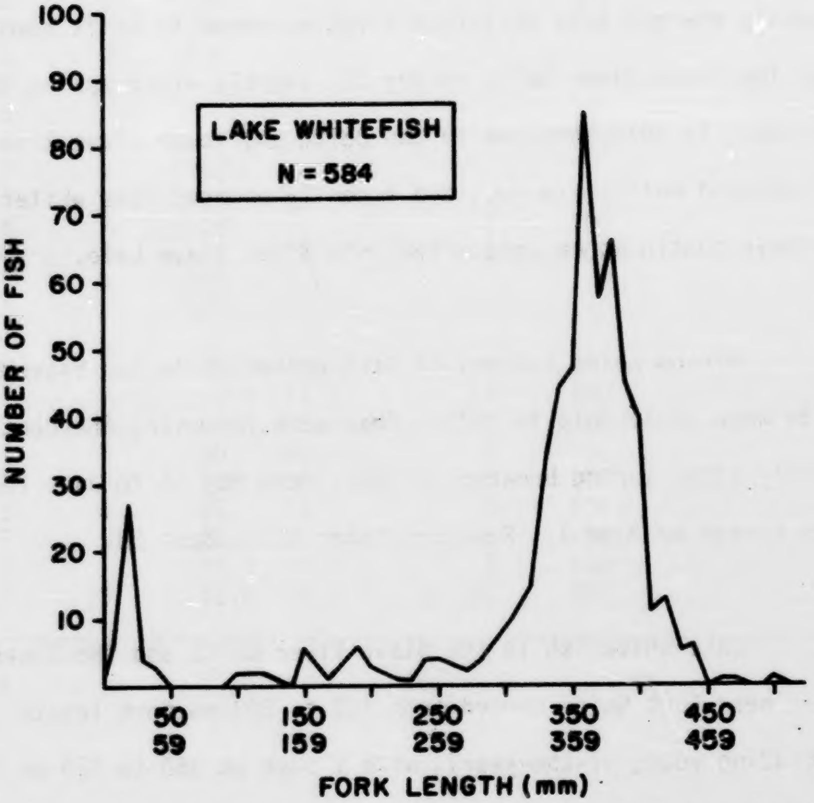

Figure 6. Length-frequency distribution of lake whitefish taken in the Slave River Delta and the Slave River, 1978 to 1980.

Table 25. Observed age-length relationship based on otoliths, age at maturity and age-specific sex ratios of the lake whitefish in the Slave River, 1978 to 1980.

Age	Fork Length (mm)			Males			Females			Unsexed	Total
	Mean	SD[a]	Range	N	%	% Mature	N	%	% Mature		
0	116.0	7.9	107-122	0	ND	ND	0	ND	ND	3	3
1	106.0	ND	ND	0	ND	ND	0	ND	ND	1	1
2	153.0	4.24	150-156	0	ND	ND	1	100	0	1	2
3	182.4	15.59	158-271	1	33	0	2	67	0	7	10
4	223.0	27.4	198-262	1	25	0	3	75	0	0	4
5	272.6	30.4	234-318	2	40	0	3	60	0	3	8
6	290.2	14.0	272-314	3	37	33	5	63	20	0	8
7	312.3	55.6	245-368	1	25	100	3	75	67	0	4
8	355.6	43.8	310-430	4	57	75	3	43	100	0	7
9	367.8	26.6	329-409	9	37	89	15	63	80	0	24
10	388.8	19.2	357-429	8	44	87	10	56	100	0	18
11	396.8	18.0	359-442	8	47	100	9	53	100	0	17
12	423.0	15.4	404-443	1	20	100	4	80	100	0	5
13	426.8	31.8	387-472	4	67	100	2	33	100	0	6
14	399.0	ND	ND	1	100	100	0	0	ND	0	1
22	503.0	ND	ND	0	0	ND	1	100	100	0	1
Total				40	43	77	54	57	69	10	104

a Standard Deviation

of the Slave River sample with those of lake whitefish in Great Slave Lake and the Mackenzie River indicates a slightly slower growth rate in the Slave River (Figure 7). Lake whitefish in the Athabasca River (not shown, Jones et al. 1978; Tripp and McCart 1980), another river spawning population, grow only slightly faster.

There were no significant differences in either the slopes ($F = 0.602$) or intercepts ($F = 3.654$) of the length-weight relationships of male and female lake whitefish in the study area. The data were therefore combined and the following relationship determined for a stratified sample consisting, where possible, of three males and three females randomly selected from each 10 mm size class:

$$\mathrm{Log}_{10}\ \text{Weight (g)} = 3.396\ \mathrm{Log}_{10}\ \text{Fork Length (mm)} - 5.856$$

$$(N = 85,\ \text{length range 162-503 mm},\ r = 0.991,\ P<0.05)$$

Sex ratios for lake whitefish in the study area did not differ from an expected 1:1 ratio at any age or overall (Table 25). Average fecundity based on 12 lake whitefish samples in the study area was 23 221 eggs, ranging from 10 643 to 38 583 (Table 26). The average fork length of the sample was 406 mm, ranging from 362 to 443 mm. Average egg size was 2.0 mm. Total gonad weight averaged 12.6% of total body weight. Regression analysis indicated

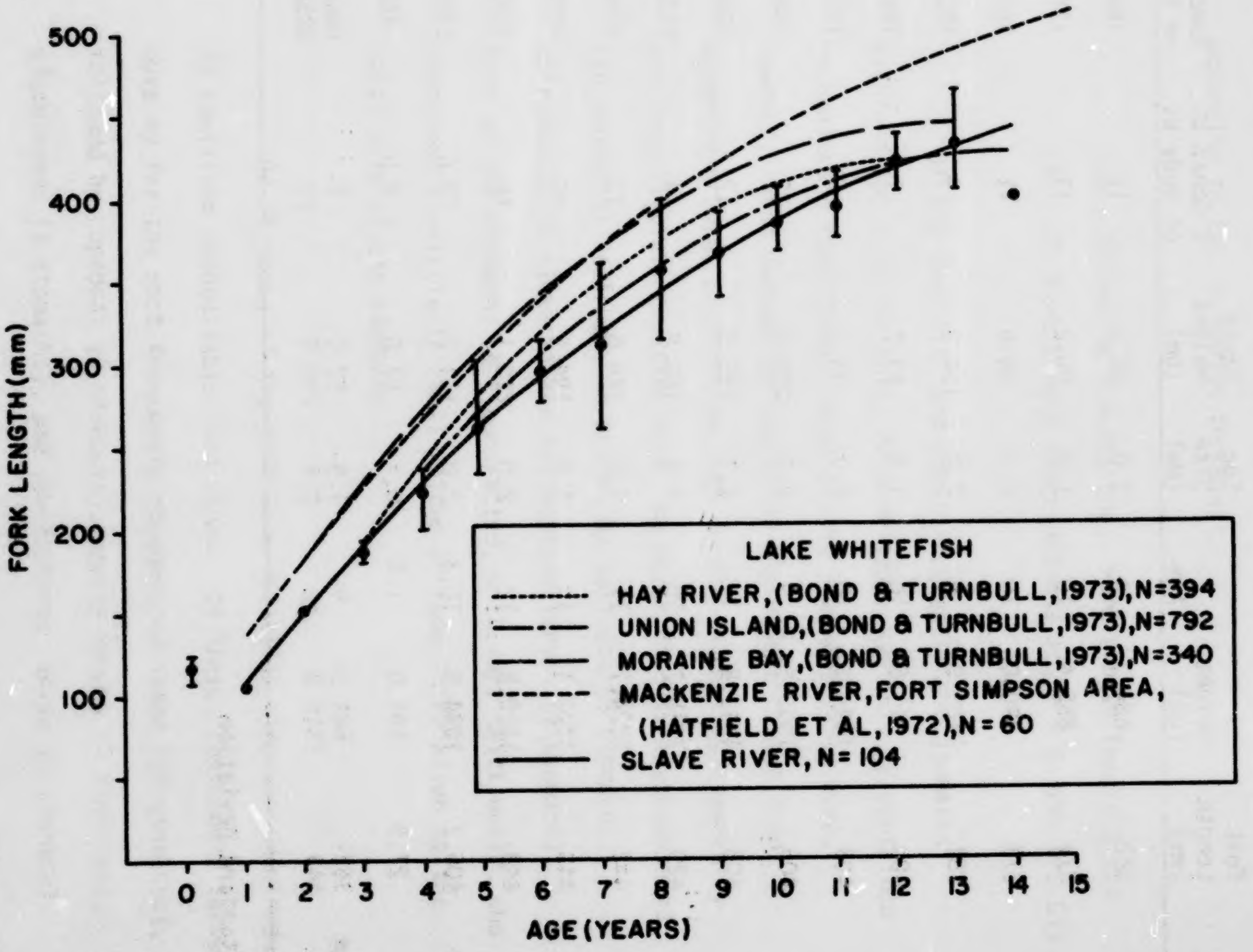

Figure 7. Comparison of the growth rate of lake whitefish in the Slave River with those in Great Slave Lake and the MacKenzie River. Points with vertical lines are mean fork lengths ±1 standard deviation. Single points are individual fish.

Table 26. Egg counts from lake whitefish taken in the Slave River Delta and in the Slave River at Fort Smith, 1979.

	Fork Length (mm)	Weight (gm)	Age	Egg Size (mm)	Gonad Weight (gm)	% Gonad Wt. of Body Wt.	Number of Eggs
	362	684.3	9	2.0	62.0	12	10643
	376	855.4	10	1.9	90.2	11	17676
	378	790.0	10	2.0	88.6	11	18278
	387	1105.0	9	2.0	104.2	9	15290
	400	961.5	10	1.9	63.3	7	16442
	403	1094.0	10	1.9	93.1	9	18029
	405	1050.6	9	2.0	230.9	22	36844
	406	1042.8	11	2.1	125.8	12	20556
	429	1216.7	10	2.0	165.5	14	27223
	442	1224.7	11	1.9	146.5	12	27802
	443	1202.1	13	1.9	194.6	16	38583
	443	1310.8	12	2.0	210.1	16	30839
Mean	406.2	1044.8	10.3	2.0	131.2	12.6	23221
SD[a]	27.9	191.0	1.2	0.1	57.8	4.0	8886
Range	362-443	684.3-1310.8	9-13	1.9-2.1	62.0-230.9	7-22	10643-38583

a Standard Deviation

a positive correlation between fecundity and fork length (mm) according to the following formula:

$$\text{Log}_{10}\ \text{Fecundity} = 4.761\ \text{Log}_{10}\ \text{Fork Length (mm)} - 8.074$$

($N = 12$, Fork Length Range 362-443 mm, $r = 0.829$, $P<0.05$).

Of 101 juvenile and adult lake whitefish stomachs examined for food contents, 72 were empty and only 29 contained recognizable food items. Most of the lake whitefish were, however, taken during the course of migrations to and from spawning grounds upriver, periods during which they apparently eat very little. Corixids were the major food item encountered (10 stomachs) followed, in order, by mollusca (9 stomachs), chironomids (1 stomach) and trichoptera larvae (1 stomach). Most of the stomachs were contracted, with very thick walls, and contained a relatively small volume of food in relation to the total size of the stomachs.

Of 46 young-of-the-year lake whitefish stomachs examined, 23 contained recognizable food items. Of these, chironomid larvae were by far the most frequently encountered items (22 stomachs), followed by copepods (8 stomachs), mayfly nymphs (3 stomachs), cladocerans (2 stomachs), and lepidopteran larvae (1 stomach).

2. Ciscoes:

During the study period, three different forms of ciscoes were captured in the Slave River Delta. The first one was similar to the large bodied lake ciscoes (*Coregonus artedii*) taken by commercial and domestic fishermen in Great Slave Lake. They were relatively rare in the Slave River Delta, accounting for less than 0.1% (N = 7) of the total catch.

The other two forms were much more common. Seldom exceeding 250 mm fork length, they were morphologically similar to least ciscoes (*Coregonus sardinella*) although some of the characters used to distinguish lake and least cisco varied greatly in the two forms. Prepelvic distance, for example, was variable in both forms, sometimes falling short of the caudal flexure when stepped off with dividers (least cisco), and sometimes falling past the caudal flexure (lake cisco).

In 1978, the first form was characterized by small body size and white pelvic fins, while the second form was characterized by a larger body size and black pelvic fins. As noted in an earlier report of these studies, three possible explanations for the existence of the two forms include:

i) two strong year classes, separated by several weak ones, with older fish developing black pelvic fins as they age;

ii) separate stocks, occupying different areas within Great Slave Lake, both of which return to the Slave River to spawn;

iii) separate but closely related sibling species.

Initially, the first explanation seemed the most likely. As shown later, the two forms appear to share the same time and place of spawning while differences in fin colour, the major reason for separating the groups, appears to be size related. Several aspects of their life histories are also similar, including their migration times, growth rates, length-weight relationships, and length-fecundity relationships.

The fish traps which were successful in capturing large numbers of ciscoes were not used after 1978. Consequently, the length-frequency distribution and relative abundance of the two forms in 1979 were not comparable to those in 1978. In 1980, a short field trip to the Slave River Delta was taken in late October solely to collect representatives of the two forms for electrophoresis analysis. Despite intensive sampling for a week with a variety of small mesh nets (1.9 cm, 2.5 cm, 3.2 cm, and 3.8 cm stretch mesh sizes), few white fin form ciscoes were taken, and none of them under 130 mm fork length. Presumably, this indicated that the once abundant small white fin form cisco had simply grown larger over the two years since 1978. It also suggested that the pelvic fins of the small white fin form cisco do in fact get progressively darker with age, increasing the likelihood that the white and black fin forms are one species.

The Mackenzie Basin Study Board will be informed of our conclusions regarding the identity of ciscoes in the Slave River Delta, when we have completed our meristic and electrophoretic analyses. The results of a preliminary electrophoretic examination of cisco muscle tissue is, however, available at this time. These results indicate that ciscoes in the Slave River Delta display two distinct banding patterns (a and b) which are different enough to be representative of two reproductively isolated populations. There are suggestions that first generation hybridization may take place between 'a' and 'b' fish, but that extensive gene flow between the two types does not occur. The type 'b' genetype was confined to the smaller (<200 mm fork length) fish, but not all small fish were type 'b', some were 'a'. Pelvic fin colour was also unrelated since both 'a' and 'b' type had white and black fins. This suggests that, while there may be two different cisco species spawning in the Delta, both start off with white fins that get progressively darker with age.

In 1978, by far the most abundant fish taken in the two traps located on Resdelta Channel and the Slave River were the small white fin (87.8% of the total catch, N = 16 695) and black fin (8.9%) form of ciscoes. The large catches were a reflection of an upstream migration of mature fish of both types, presumably to spawning areas located upstream. For both forms of ciscoes, fish first appeared in the traps in mid-September and catches peaked between October 15 and 25 (Figure 8). Some fish of both types were still being taken on November 6 and 7 when the traps were removed because of adverse icing conditions.

Catches in the downstream traps (Figure 9) were much smaller than those in the upstream ones and likely composed of fish which had returned a short distance downstream after having passed through or around the leads. As a result, seasonal variation in catches in the downstream traps closely paralleled those in the upstream traps. There was no evidence of a concerted downstream movement of spawned-out fish by the time the traps were removed in early November.

Most of the fishing effort during the cisco run in 1978 was spent monitoring catches in the two fish traps. Consequently, there was little information on the relative importance of other channels to ciscoes migrating upstream. Intensive gillnetting

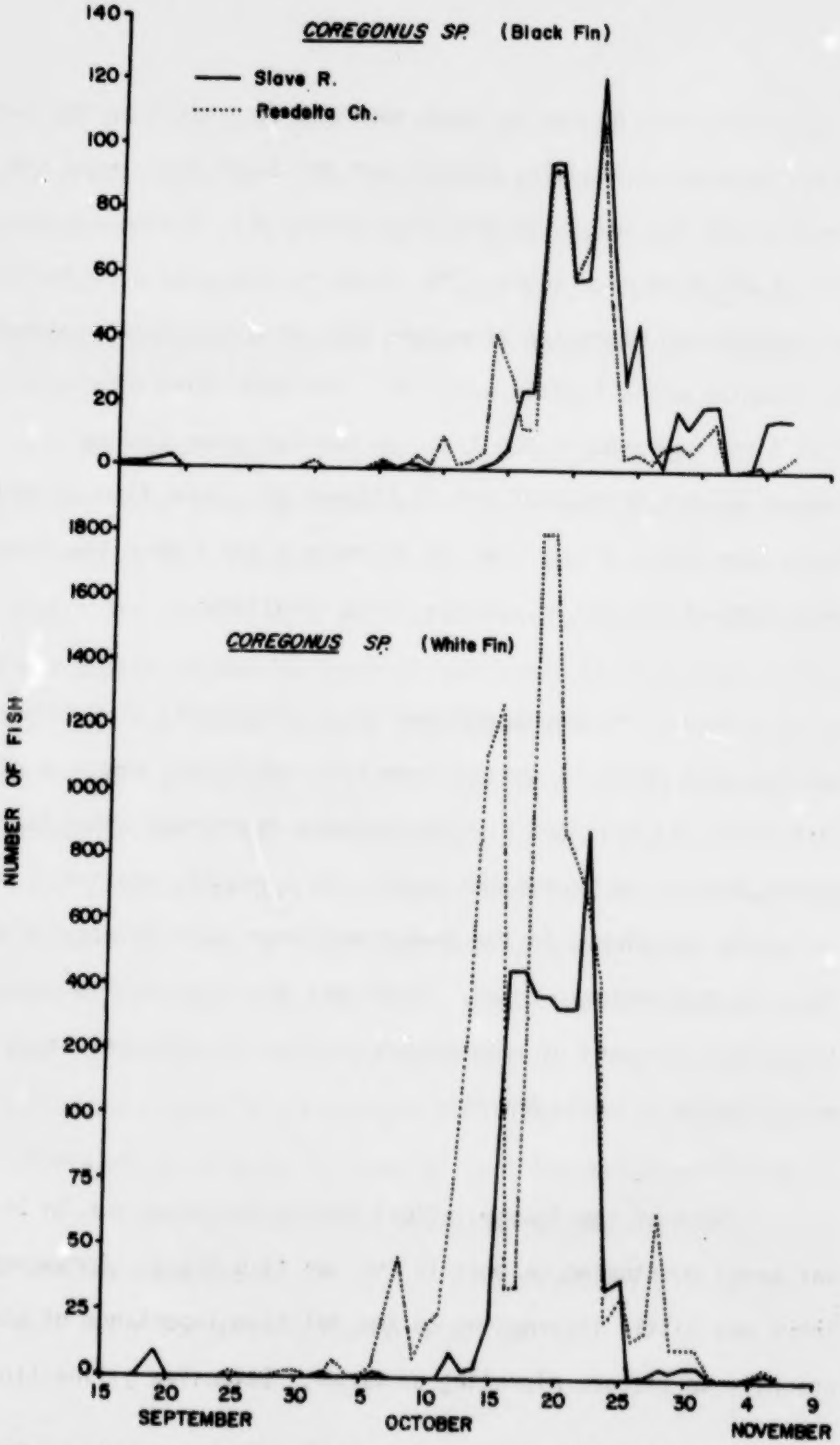

Figure 8. Seasonal variation in catches of the black and white fin form of ciscoes in upstream traps on Resdelta Channel and the lower Slave River, September to November, 1978.

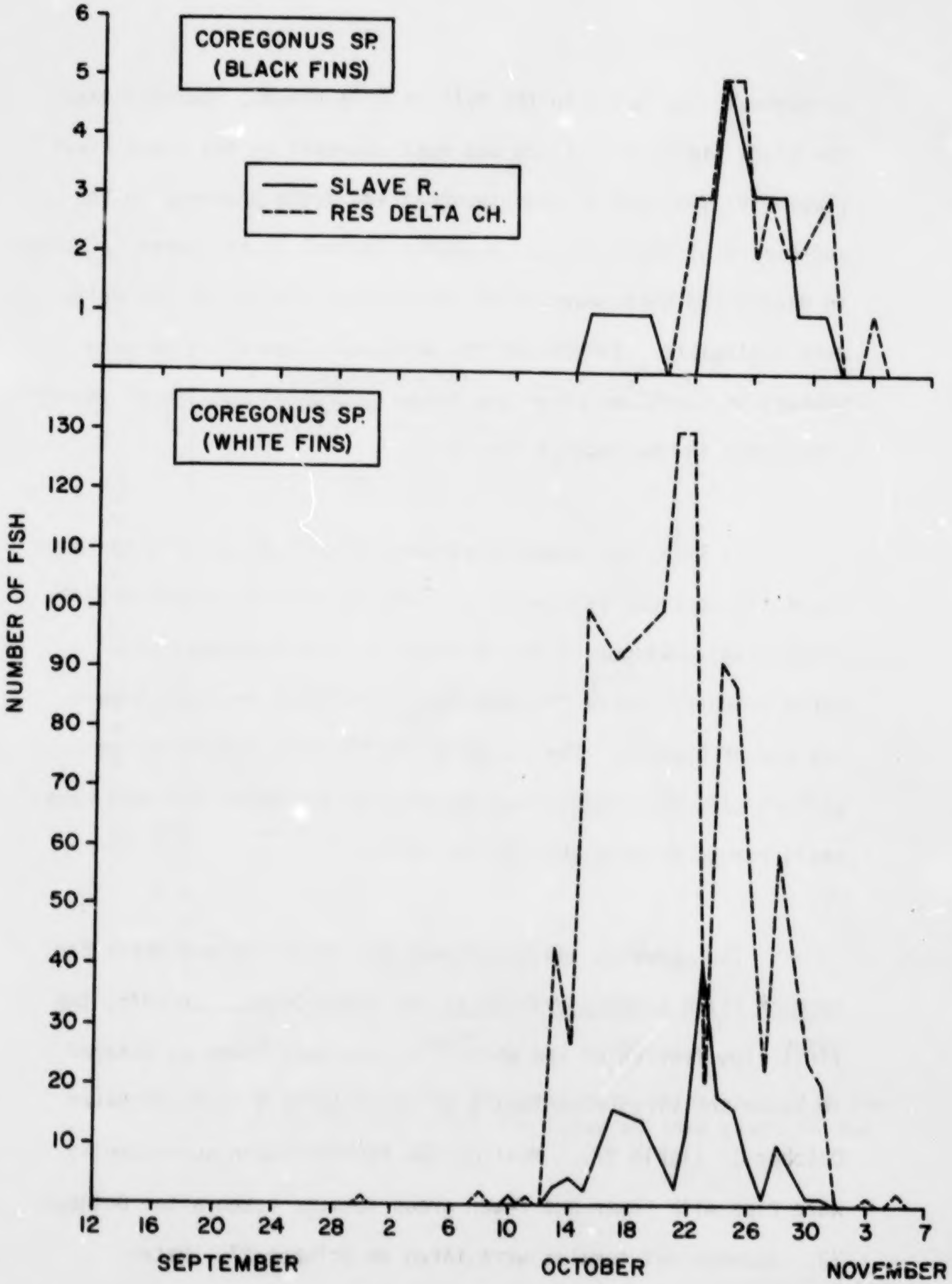

Figure 9. Seasonal variations in catches of the black and white fin form of ciscoes in downstream traps on Resdelta Channel and the lower Slave River, September to November, 1978.

throughout the Delta in the fall of 1979 showed, however, that the black fin form of cisco was most abundant in the Slave River (Table 16) followed by Old Steamboat and Nagle channels in the south part of the Delta and Resdelta Channel in the north. Catches in Middle and East channels in the central portion of the Delta were negligible. Catches of the white fin form of cisco were highest in the Slave River and Resdelta Channel and low or absent altogether in the rest of the Delta.

In 1979, the seasonal pattern of gillnet catches for both forms of cisco was similar to catches in the fish traps in 1978 (Figure 10). Ciscoes first appeared in late September and early October, peaked in mid-October, and then declined toward the end of October. The larger black fin form dominated the gillnet catches probably because most of the white fin form were small enough to pass through the meshes.

The spawning season of both the white fin and black fin form of cisco broadly overlap in the Slave Delta. In 1978, the first ripe females of the white fin form were taken on October 10 while the first ripe female of the black fin form was taken October 14 (Table 27). Most of the females taken subsequently were ripe with fewer and fewer green females taken after October 23. Spawned-out females were taken on October 27. Water

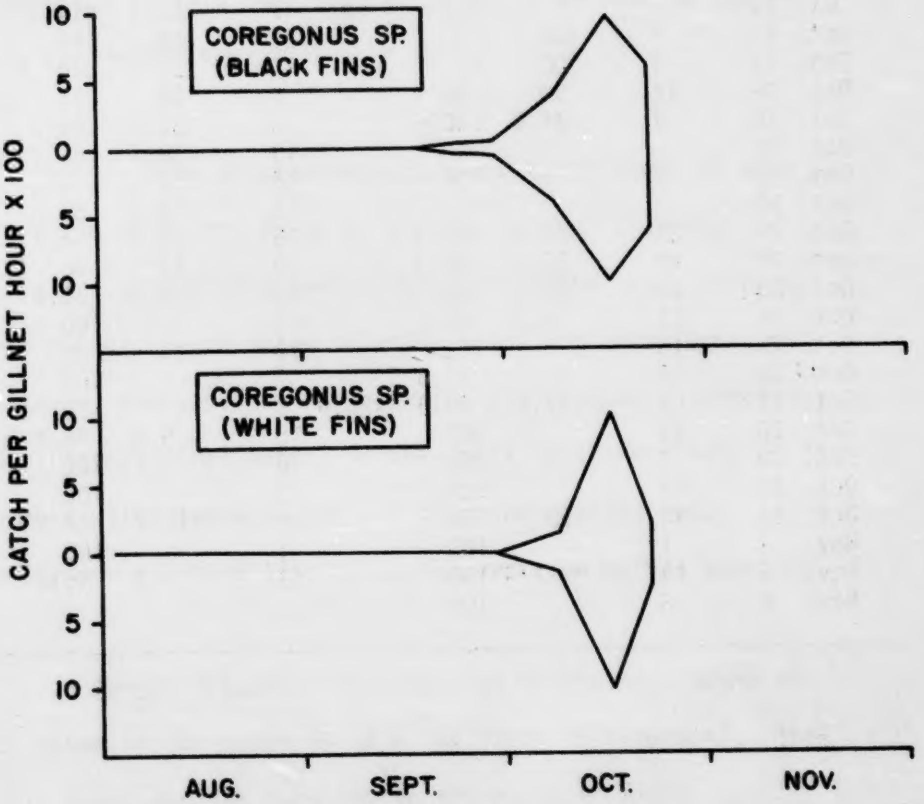

Figure 10. Seasonal patterns of catch per gillnet hour for the white fin and black fin forms of lake cisco in the Slave Delta, 1979.

Table 27 . The spawning condition of female ciscoes (black fin and white fin) taken in the Slave River Delta, October 8 to November 6, 1978. N=number of fish, G=green, R=ripe, SO=spawned out.

	FEMALES-Black Fin				FEMALES-White Fin				Water Temp. (°C)
Date	N	%G	%R	%SO	N	%G	%R	%SO	
1978									
Oct. 8	1	100							7.2
Oct. 9					2	100			7.2
Oct. 10	2	100			4	75	25		7.2
Oct. 11					7	85.7	14.3		6.7
Oct. 12	1	100			32	50	50		6.1
Oct. 13	2	100			15	20	80		5.6
Oct. 14	12	50	50		8	25	75		5.0
Oct. 15	3	33.3	66.6		8	37.5	62.5		4.4
Oct. 17					13	38.5	61.5		3.9
Oct. 19	1		100		16	25	75		4.4
Oct. 20					11	18.2	81.8		3.9
Oct. 21	23	26.1	73.9		15	13.3	86.7		3.3
Oct. 22	28	35.7	64.3		10	10	90		2.8
Oct. 23	20	20	80		12	33.3	66.6		2.8
Oct. 24	15	6.7	93.3		11		100		2.8
Oct. 25	10		100		10	10	90		2.8
Oct. 26	6	16.7	83.3		7		100		2.2
Oct. 27	7	42.8	28.6	28.6	8		75	25	2.2
Oct. 28	15		100		18	5.6	94.4		2.2
Oct. 29	7		100		10		100		1.7
Oct. 30	17		100		12		100		1.7
Oct. 31	10	10	90		9	11.1	88.9		1.7
Nov. 3	1		100		1		100		1.1
Nov. 5	14		100		3	33.3	66.6		0.6
Nov. 6	8		100						0.6

temperatures from the time the first ripe females were taken to the time the first spent females were taken ranged from 7.2 to 2.2 C.

Seasonal variations in the spawning condition of both forms of cisco in 1979 were similar to those in 1978, although the data are fewer (Table 28).

The presence of extremely large concentrations of both the black and white fin forms of ciscoes in ripe spawning condition indicate that Resdelta Channel and the lower reaches of the Slave River are major spawning areas for both forms. It is not known, however, how far upstream their spawning areas may extend. Ciscoes first appear in the delta relatively late in the season when water temperatures are dropping rapidly and, presumably, do not have time to go far upstream before spawning.

The length-frequency distribution of ciscoes, based on samples taken in the traps in 1978, is shown in Figure 11. The white fin form, ranging from 100 to 189 mm fork length, was considerably more abundant than the black fin form which ranged from 130 to 279 mm fork length. The overall distribution was distinctly bimodal, with most of the white fin form falling in the 130 to 149 mm range and most of the black fin form falling in the 220 to 239 mm range.

Table 28. The spawning condition of female ciscoes (black fin and white fin) taken in the Slave River Delta, October 5 to October 24, 1979. N=number of fish, G=green, R=ripe, SO=spawned out.

Date	FEMALES-Black Fin N	%G	%R	%SO	FEMALES-White Fin N	%G	%R	%SO	Water Temp. (°C)
1979									
Oct. 5	2		100						8.0
Oct. 6	3	66.6	33.3						7.5
Oct. 7	1		100						7.5
Oct. 8	1		100		1		100		7.0
Oct. 10	3	33.3	66.6						6.5
Oct. 12	4		100		2		100		6.5
Oct. 15	3		100		1		100		6.5
Oct. 16	12	8.3	91.7		2		100		7.0
Oct. 17	7		100		4		100		6.0
Oct. 20	2		100						5.5
Oct. 21	5		100						5.0
Oct. 22	3		100						5.0
Oct. 23	4		100						5.0
Oct. 24	1		100						4.5

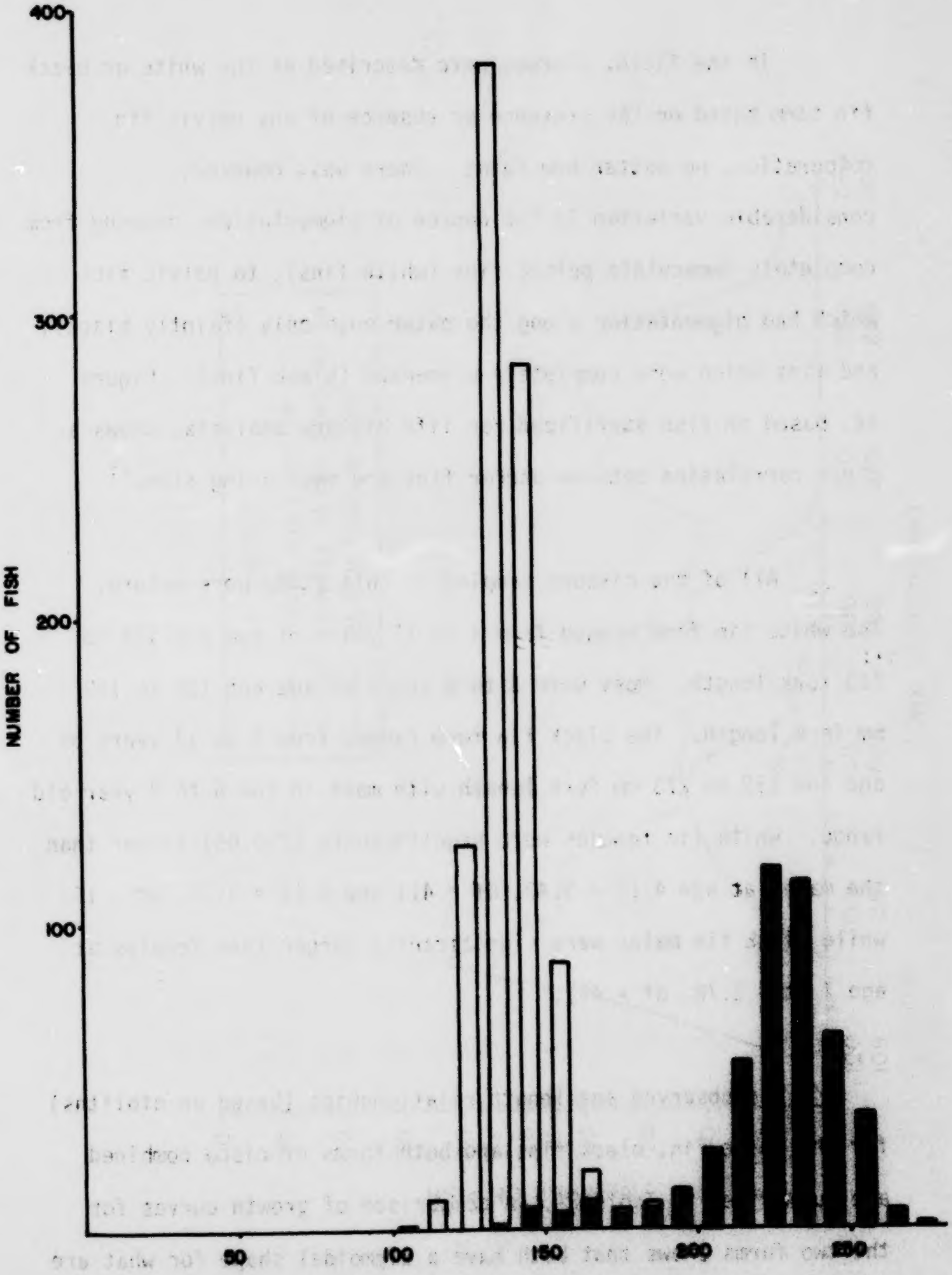

Figure 11. Length-frequency distribution of the black and white fin form of ciscoes taken in the traps on Resdelta Channel and the lower Slave River, September to November, 1978.

In the field, ciscoes were described as the white or black fin form based on the presence or absence of any pelvic fin colouration, no matter how faint. There was, however, considerable variation in the degree of pigmentation, ranging from completely immaculate pelvic fins (white fins), to pelvic fins which had pigmentation along the outer edge only (faintly black), and fins which were completely pigmented (black fins). Figure 12, based on fish sacrificed for life history analysis, shows a clear correlation between darker fins and increasing size.

All of the ciscoes sampled in this study were mature. The white fin form ranged from 1 to 11 years of age and 104 to 183 fork length. Most were 3 to 6 years of age and 125 to 150 mm fork length. The black fin form ranged from 4 to 13 years of age and 132 to 273 mm fork length with most in the 6 to 8 year old range. White fin females were significantly ($P<0.05$) larger than the males at age 4 ($t = 3.40$, $df = 41$) and 5 ($t = 3.37$, $df = 16$) while black fin males were significantly larger than females at age 7 ($t = 2.78$, $df = 49$).

The observed age-length relationships (based on otoliths) for the white fin, black fin, and both forms of cisco combined are summarized in Table 29. A comparison of growth curves for the two forms shows that both have a sigmoidal shape for what are

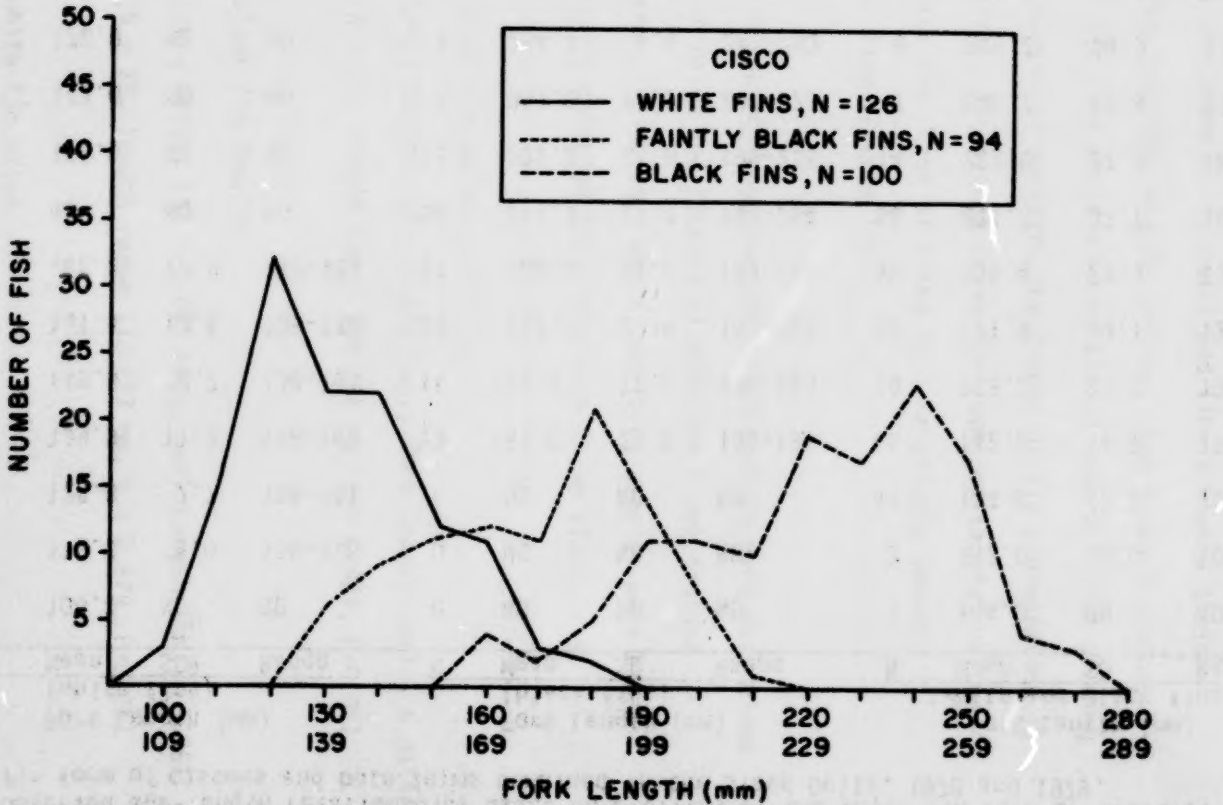

Figure 12. Length-frequency distribution of the white fin and black fin form of lake ciscoes taken for detailed dissection in the Slave Delta, 1978.

Table 29. Observed age-length relationships based on otoliths of the white fin form of ciscoes, black fin form of ciscoes and both forms combined in the Slave Delta, 1978 and 1979.

Age	Fork Length (mm) (white fins)				Fork Length (mm) (black fins)				Fork Length (mm) (white and black fins)			
	N	Mean	SD[a]	Range	N	Mean	SD	Range	N	Mean	SD	Range
1	1	104.0	ND[b]	ND	0	ND	ND	ND	1	104.0	ND	ND
2	3	112.0	6.0	106-118	0	ND	ND	ND	3	112.0	6.0	106-118
3	43	124.8	7.7	106-141	0	ND	ND	ND	43	124.8	7.7	106-141
4	52	139.9	11.3	116-167	13	151.5	20.0	132-194	65	142.2	14.1	116-194
5	18	149.5	8.7	136-161	11	159.6	12.2	139-180	29	153.3	11.2	136-180
6	20	151.4	12.4	125-178	32	184.7	29.4	143-252	52	171.9	29.1	125-252
7	7	162.0	17.8	137-183	51	200.0	27.6	153-244	58	195.4	29.3	137-244
8	0	ND	ND	ND	56	211.7	27.7	162-254	56	211.7	27.7	162-254
9	1	166.0	ND	ND	13	227.3	23.0	190-255	14	222.9	27.5	166-255
10	1	173.0	ND	ND	6	257.8	11.9	244-273	7	245.7	33.9	173-273
11	1	170.0	ND	ND	5	254.2	6.8	245-263	6	240.2	34.9	170-263
12	0	ND	ND	ND	2	254.5	6.4	250-259	2	254.5	6.4	250-259
13	0	ND	ND	ND	1	273.0	ND	ND	1	273.0	ND	ND
Total	147				190				337			

a Standard Deviation
b No Data

probably related reasons. The sample size for age 1 and 2 white fin ciscoes, for example, is small and likely biased toward faster growing fish that mature earlier. Age 4 and 5 ciscoes of the black fin form could also be biased toward faster growing fish if, as suggested earlier, the degree of fin pigmentation is related to size. The growth curve for combined samples of the white and black fin forms of cisco is a relatively smooth, uninterrupted line (Figure 13).

The following length-weight relationships were determined separately for males and females of both the black fin and white fin forms of ciscoes. Where possible, samples were based on three randomly selected fish from each 10 mm size class.

i) black fin males

Log_{10} Weight (g) = 2.961 Log_{10} Fork Length (mm) - 5.0114

(N = 27, length range 134-284 mm, r = 0.984, $P<0.05$)

ii) black fin females

Log_{10} Weight (g) = 3.081 Log_{10} Fork Length (mm) - 5.267

(N = 29, length range 132-273 mm, r = 0.979, $P<0.05$)

iii) white fin males

Log_{10} Weight (g) = 2.974 Log_{10} Fork Length (mm) - 5.063

(N = 24, length range 104-183 mm, r = 0.945, $P<0.05$)

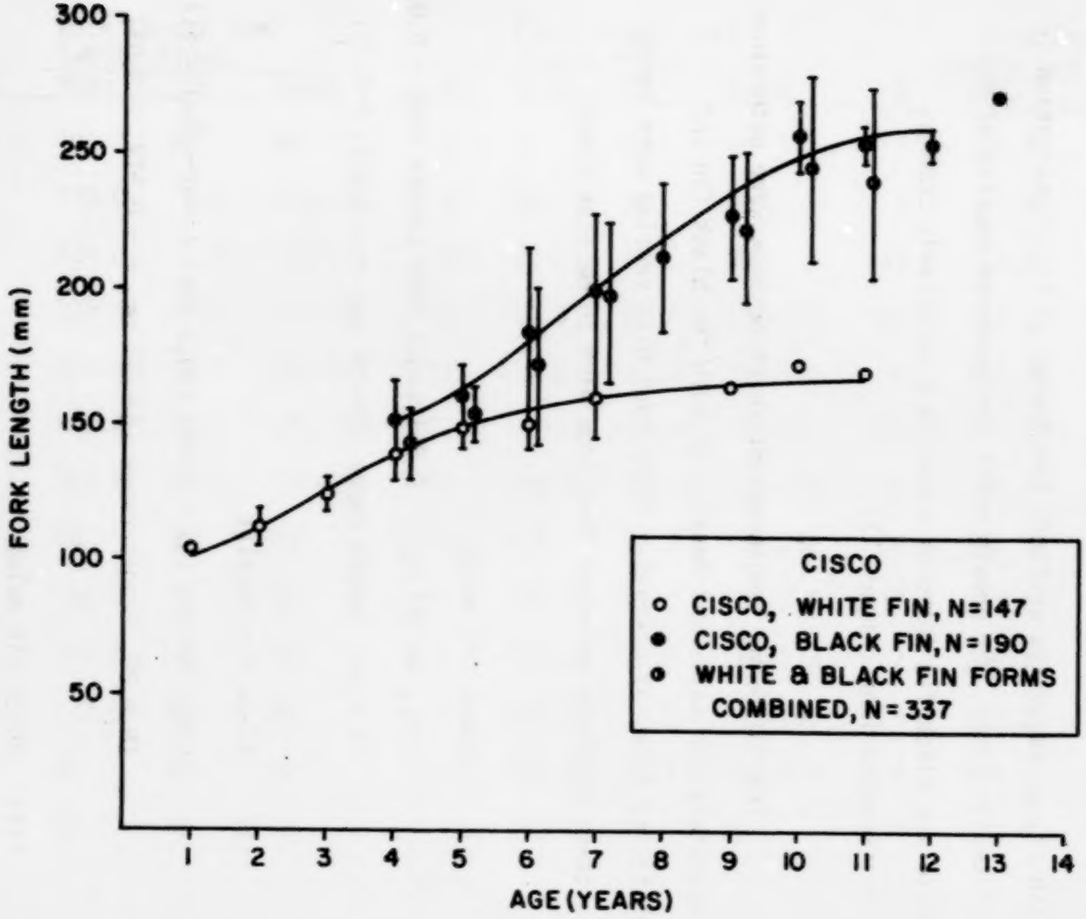

Figure 13. Comparison of growth rates for the white fin form, black fin form and both forms of lake cisco combined in the Slave Delta, 1978. Points and vertical bars are mean fork length ±1 standard deviation. Single points are individual fish.

iv) white fin females

Log_{10} Weight (g) = 3.034 Log_{10} Fork Length (mm) - 5.182

(N = 18, length range 115-173, r = 0.973, $P<0.05$)

Analysis of covariance (ANCOVA) demonstrated a significant difference between the slopes (F = 6.50) of the length-weight relationship for black fin males and females, but not the intercepts (F = 0.526). This indicates that at any given length within the sample range, the female black fin form of cisco is heavier than the male. There were no significant differences between the length-weight relationships for both forms of cisco, males and females combined are:

v) black fin (males and females)

Log_{10} Weight (g) = 3.074 Log_{10} Fork Length (mm) - 5.263

(N = 56, length range 132-284 mm), r = 0.980, $P<0.05$)

vi) white fin (males and females)

Log_{10} Weight (g) = 3.006 Log_{10} Fork Length (mm) - 5.126

(N = 42, length range 104-183 mm, r = 0.954, $P<0.05$)

A comparison of the two relationships (v and vi) showed no significant differences in either slopes (F = 0.180) or intercepts (F = 0.385). The length-weight relationship for both the white fin and black fin form of ciscoes combined is:

vii) white fin and black fin combined

Log_{10} Weight (g) = 3.043 Log_{10} Fork Length (mm) - 5.193

($N = 131$, range 104-184 mm, $r = 0.987$, $P<0.05$)

Sex ratios, based only on fish for which both age and sex were determined, differed significantly from an expected 1:1 ratio at age 3 and overall for the white fin form (Table 30). The differences probably reflect an earlier age at first maturity for males. Females were significantly more abundant than males at age 5 for the black fin form. The sample size was, however, small ($N = 11$).

Fecundities were determined for 26 of the black fin form and 17 of the white fin form. The average fecundity for the black fin form was 3843 eggs (range 708-10 573, Table 31). Average fork length of the sample was 208 mm ranging from 142 to 273 mm. Total gonad weight accounted for, on the average, 11.0% of total body weight.

The average fecundity for the white fin form was 1357 eggs ranging from 506 for a female 141 mm in fork length, to 2669 for a female 155 mm in fork length (Table 32). Average fork length

Table 30. Age specific sex ratios for the white fin and black fin form of ciscoes in the Slave Delta.

	White Fin Form			Black Fin Form		
Age	No. of Males	No. of Females	χ^2	No. of Males	No. of Females	χ^2
1	1	0	-	0	0	-
2	3	0	-	0	0	-
3	40	3	31.84[a]	0	0	-
4	30	22	1.24	6	7	0.08
5	10	8	0.22	2	9	4.45[a]
6	10	10	0.00	13	19	1.12
7	2	5	1.29	32	19	3.31
8	0	0	-	29	27	0.08
9	1	0	-	8	5	0.69
10	0	1	-	2	4	-
11	0	1	-	1	4	-
12	0	0	-	1	1	-
13	0	0	-	0	1	-
Total	97	50	15.03[a]	94	96	0.02

[a] Significant deviation from an expected 1:1 ratio

Table 31. Egg counts from the black fin form of cisco taken in the Slave River, 1978 and 1979.

Fork Length (mm)	Weight (gm)	Age	Egg Size (mm)	Gonad Weight (gm)	% Gonad Wt. of Body Wt.	Number of Eggs
142	25.3	4	1.6	4.2	17	1930
146	23.6	6	1.2	2.6	11	708
159	31.9	5	1.6	4.1	13	1375
160	34.1	7	1.5	4.2	12	1314
166	37.0	6	1.5	4.7	13	1304
172	39.4	7	1.6	7.7	7	2702
172	43.5	-	1.4	3.4	8	1390
176	47.0	7	1.5	5.1	11	1619
177	40.3	8	1.5	3.3	8	899
180	40.8	7	1.4	4.7	12	9693
185	58.0	5	1.5	7.1	12	1512
190	55.6	6	1.4	7.4	13	2285
194	74.4	4	2.0	6.6	9	981
209	72.3	8	1.5	8.6	12	2940
214	79.9	7	1.4	7.7	10	1979
220	85.7	8	1.5	10.0	12	4238
233	110.2	9	1.5	13.2	12	8203
236	106.4	8	1.4	12.5	13	4338
241	113.6	8	1.6	7.9	7	2854
252	148.3	9	1.6	19.2	13	5869
253	129.3	8	1.5	13.3	10	6188

Continued

Table 31. Continued.

	Fork Length (mm)	Weight (gm)	Age	Egg Size (mm)	Gonad Weight (gm)	% Gonad Wt. of Body Wt.	Number of Eggs
	262	179.4	8	1.5	22.0	12	10573
	263	162.0	11	1.5	15.3	9	5388
	264	132.0	8	1.4	10.4	8	3172
	270	170.6	10	1.5	22.8	13	9173
	273	165.0	10	1.6	15.5	9	7290
Mean	208.0	84.8	7.4	1.5	9.4	11.0	3843
SD[a]	42.4	50.9	1.8	0.1	5.8	2.4	3009
Range	142- 273	23.6- 179.4	4- 11	1.2- 2.0	2.6- 22.8	7- 17	708- 10573

a Standard Deviation

Table 32. Egg counts from the white fin form of cisco taken in the Slave Delta, 1978 and 1979.

	Fork Length (mm)	Weight (gm)	Age	Egg Size (mm)	Gonad Weight (gm)	% Gonad Wt. of Body Wt.	Number of Eggs
	127	15.0	4	1.5	1.4	9	653
	137	18.6	7	1.5	2.3	12	1072
	137	21.7	4	1.5	3.6	17	998
	138	20.4	4	1.5	3.3	16	946
	141	21.5	4	1.6	3.8	18	506
	142	22.6	4	1.5	2.7	12	752
	147	24.4	5	1.5	3.8	16	1444
	147	25.0	4	1.2	2.1	8	1625
	154	29.0	5	1.2	2.8	10	2438
	155	28.1	7	1.6	4.8	17	2669
	157	30.9	5	1.3	3.1	10	645
	160	36.2	4	1.4	1.9	5	1146
	161	30.4	7	1.6	3.6	12	614
	166	33.1	6	1.5	5.2	16	1780
	167	40.0	4	1.6	5.5	14	2227
	170	35.1	11	1.5	3.8	11	1716
	170	35.8	6	1.6	5.0	14	1838
Mean	151.5	27.5	5.3	1.5	3.5	12.8	1357
SD[a]	13.2	7.1	1.9	0.1	1.2	3.7	677
Range	127- 170	15.0- 40.0	4- 11	1.2- 1.6	1.4- 5.5	5- 18	506- 2669

a Standard Deviation

of the sample was 151 mm (range 127-170 mm). Total gonad weight accounted for approximately 12.8% of the total body weight.

Fecundity was positively correlated with fork length for both forms of cisco according to the following equations:

i) black fin form

Log_{10} Fecundity = 2.972 Log_{10} Fork Length (mm) - 3.408

($N = 26$, range 142-273 mm, $r = 0.5219$, $P<0.05$)

ii) white fin form

Log_{10} Fecundity = 3.090 Log_{10} Fork Length (mm) - 3.653

($N = 17$, range 127-170 mm, $r = 0.7606$, $P<0.05$)

There were no significant differences in either slopes ($F = 0.005$) or intercepts ($F = 0.030$) for the length-fecundity relationships of the two forms. The length-fecundity relationship for both forms combined (Figure 14) was:

iii) white and black fin forms combined

Log_{10} Fecundity = 2.936 Log_{10} Fork Length (mm) - 3.322

($N = 43$, range 127-273 mm, $r = 0.803$, $P<0.05$)

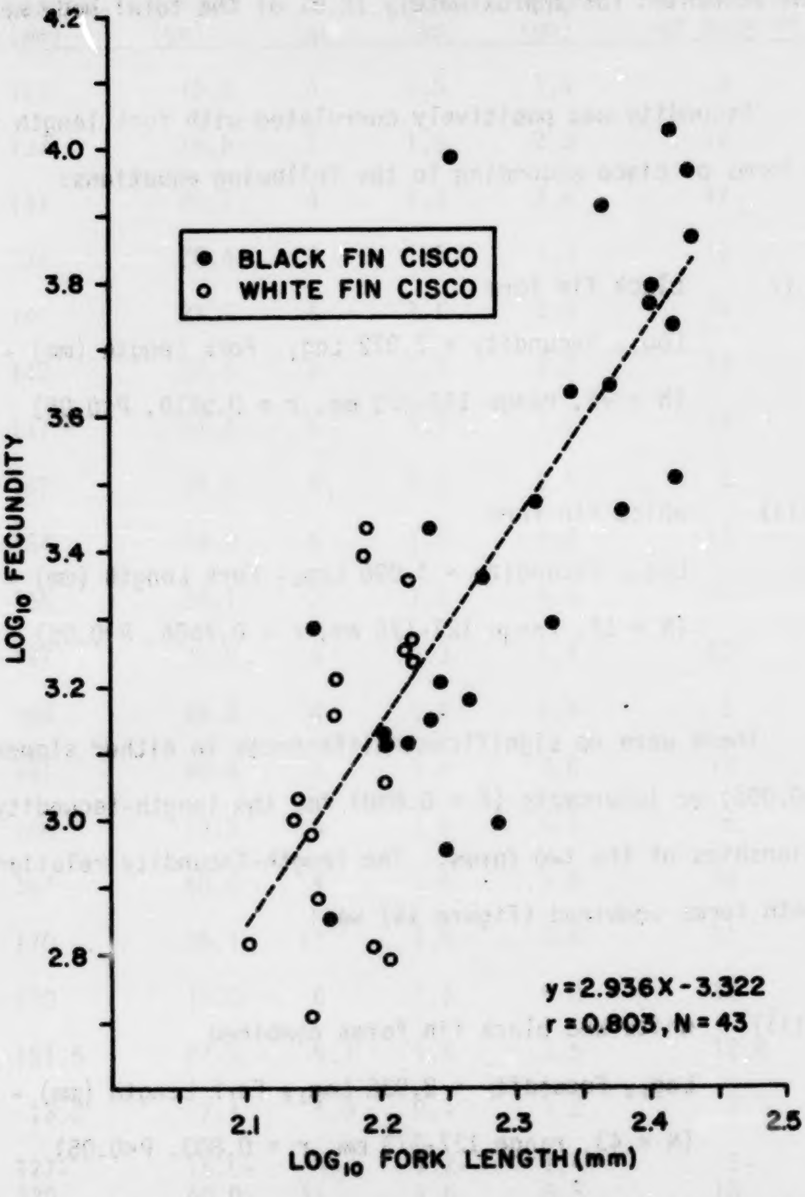

Figure 14. Length-fecundity relationships for the white and black fin form of ciscoes in the Slave Delta, 1978.

Of 29 cisco stomachs examined for food contents, 13 were found to contain food. Chironomid larvae and mysids were the most common items eaten, occurring in 46 and 23 percent of the stomachs containing food. Other items consumed included corixids, cladocerans, and amphipods.

3. Inconnu:

In North America, the inconnu (*Stenodus leucichthys*) ranges south in Bering Sea drainages to the Kuskokwin River and east in Arctic Ocean drainages to the Anderson River (McPhail and Lindsey 1970). It ascends the Yukon River to its headwaters in Teslin Lake, B.C., and the Mackenzie River as far as Fort Nelson on the Liard River and the rapids at Fort Smith on the Slave River.

In Great Slave Lake, the inconnu is the most valuable commerical species taken after lake whitefish and lake trout (Moshenko and Low 1979). It is probably even more valuable to the domestic fisheries of the region as a source of human and dog food. Spawning occurs in the fall following a prolonged and gradual upstream movement which peaks at different times during the summer depending on the location and the length of the migration (Stein et al. 1973). After spawning, which is reported to take place in clear tributaries over coarse gravel substrates (Alt 1969), a marked downstream run occurs. The largest runs in the Great

Slave Lake region are reported in the Buffalo and Taltson rivers with smaller runs in the Slave, Hay, and Little Buffalo rivers (Scott and Crossman 1973).

In the Slave River Delta, inconnu represented only 1.0% (N = 50) of the total gillnet catch, almost all of which were taken in Resdelta Channel and the lower Slave River (Table 16). The seasonal variation in gillnet catches of inconnu (Figure 15) indicates that they are virtually absent from the Slave Delta during the spring. The highest catches are recorded in late August and are thought to represent a migration of fish to spawning areas upstream. A secondary peak in late October, composed largely of spent fish, likely coincides with a sudden downstream movement after spawning.

The spawning areas of inconnu in the Slave River are unknown. A major spawning area is, however, suspected at the base of the rapids on the Slave River near Fort Smith. As shown for lake whitefish, domestic gillnet catches were very high in this area, with inconnu accounting for approximately 10% of the total catch.

Limited spawning may also occur in the vicinity of the Slave River Delta and lower Slave River as indicated by the capture

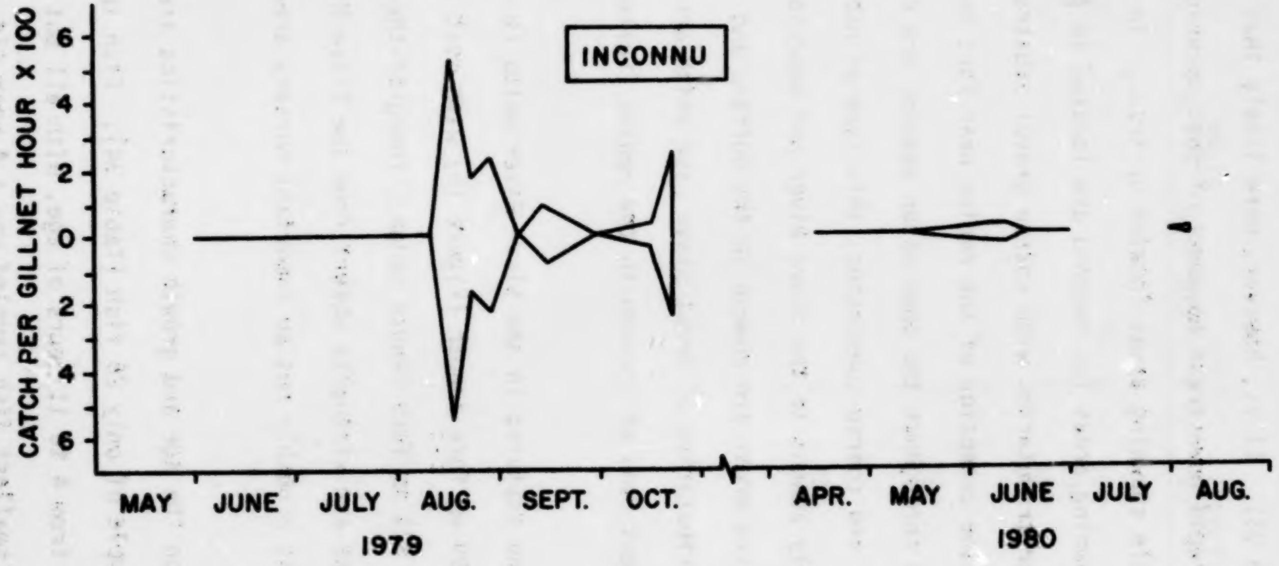

Figure 15. Seasonal pattern of catch per gillnet hour for inconnu taken from the Slave River Delta, 1979 and 1980.

of several ripe and recently spawned-out females on October 23 and 24 (Table 33). It is, however, more likely that these fish represent a rapid downstream movement of post spawning fish from more favourable spawning areas located upstream. In Alaska, preferred spawning areas for inconnu are located in the fast water of clear tributaries with coarse gravel substrates (Alt 1969). With the exception of the rapids near Fort Smith, which though turbid throughout the open water season, are characterized by fast water and coarse substrates, this type of habitat is almost entirely absent in the Slave River and especially the Slave Delta. Spawning areas are common in the Buffalo and Talston rivers, two tributaries of Great Slave Lake which are reported to have the largest runs of inconnu in the region (Fuller 1955).

Inconnu captured in the Slave River Delta (N = 50) ranged from 325 to 899 mm fork length (Figure 16) with most (59%) falling in the 775 to 874 mm fork length range. Young-of-the-year and small juveniles are virtually absent from the Slave River Delta and the area is probably not an important nursery area.

Data on the age and growth characteristics are tentative, based on a sample of only 26 fish (Table 34). Fish in the aged sample ranged from 4 to 11 years of age, with all but three aged 8 to 10. The smallest fish sampled was a 4 year old, immature

Table 33. The spawning condition of inconnu taken in the Slave River Delta and the Slave River at Fort Smith, August 22 to November 6, 1979. N=number of fish, G=green, R=ripe, SO=spawned out.

	MALES				FEMALES				Water Temp.
Date	N	%G	%R	%SO	N	%G	%R	%SO	(°C)
Slave Delta									
Aug. 22	3	100			1	100			15.0
Aug. 29	3	100			4	100			12.8
Sept 25					1	100			8.3
Oct. 22					1			100	5.0
Oct. 23					4		25	75	5.0
Oct. 24					1		100		4.5
Oct. 29					1	100			2.2
Nov. 6					1			100	0.6
Fort Smith									
Oct. 2					5	100			ND[a]
Oct. 9					1	100			7.5

[a] No Data

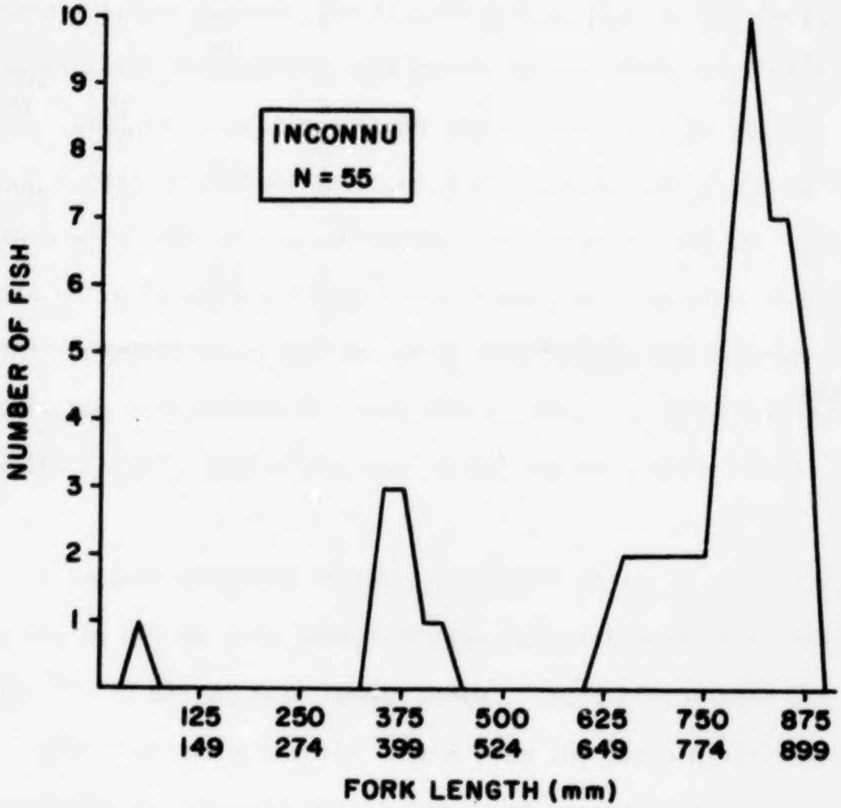

Figure 16. Length-frequency distribution of inconnu in the Slave River Delta and Slave River, 1978 to 1980.

Table 34. Observed age-length relationship based on otoliths, age at maturity and age-specific sex ratios for inconnu in the Slave Delta, 1978 to 1980.

Age	Fork Length (mm)			Males			Females			Unsexed	Total
	Mean	SD[a]	Range	N	%	% Mature	N	%	% Mature		
4	369.0	ND[b]	ND	0	0	ND	1	100	0	0	1
6	658.0	ND	ND	1	100	100	0	0	ND	0	1
8	724.6	55.5	681-818	3	60	100	2	40	100	0	5
9	822.0	41.2	740-866	1	11	100	8	89	100	0	9
10	819.3	42.0	770-892	3	33	100	6	67	100	0	9
11	824.0	ND	ND	0	0	ND	1	100	100	0	1
Total				8	31	100	18	69	94	0	26

a Standard Deviation

b No Data

female, 369 mm in fork length. The rest were all mature, the largest being a 10 year old female, 892 mm in fork length. A comparison of growth rates shows a faster growth rate for inconnu in the Slave River than those reported for Great Slave Lake (Fuller 1955), the Mackenzie River (Hatfield et al. 1972), the Mackenzie Delta (Percy 1975; de Graaf and Machniak 1976), and Kobuk River, Alaska (Alt 1969). There was, however, considerable difficulty in determining the location of early annuli in otoliths of inconnu from the Slave Delta and the apparently faster growth rate may be due to underaging of fish from this area.

The length-weight relationship for inconnu sampled from the Slave River Delta and the Slave River at Fort Smith was:

$$\text{Log}_{10}\ \text{Weight (g)} - 2.989\ \text{Log}_{10}\ \text{Fork Length (mm)} - 4.917$$

$$(N = 24, \text{ length range } 309\text{-}873 \text{ mm}, r = 0.990, P<0.05)$$

The sex ratio of the inconnu sampled did not differ significantly ($P>0.05$) from an expected 1:1 ratio. The sample size ($N = 26$) was, however, very small.

The average fecundity of nine inconnu taken from the Slave Delta and the Slave River at Fort Smith was 120 907, ranging from 72 282 for a female 826 mm in fork length to 164 444 for a female 855 mm in length (Table 35). Average fork length of the sample was 824 mm. Egg size varied from 1.7 mm for inconnu taken in late August in the Slave Delta to 2.5 for inconnu taken in early October at Fort Smith. Fecundity was significantly correlated ($r = 0.854$, $P<0.05$) with body length according to the following equation:

$$\mathrm{Log}_{10}\ \mathrm{Fecundity} = 1.659\ \mathrm{Log}_{10}\ \mathrm{Fork\ Length\ (mm)} + 0.2337$$

Only 6 of 37 inconnu stomachs examined were found to contain food. Fish remains were the only recognizable items, including ciscoes, northern pike, and walleye.

4. Goldeye:

In the Mackenzie Basin, goldeye (*Hiodon alosoides*) are abundant throughout most of the Athabasca River, the Peace-Athabasca Delta, the Peace River, and the Slave River, but are relatively rare in both Great Slave Lake (Rawson 1951; Bond and Turnbull 1973) and the Mackenzie River (Hatfield et al 1972; Stein et al. 1973). They have, however, been taken as far north as the Mackenzie Delta.

Table 35. Egg counts from inconnu taken in the Slave River Delta and Slave River, 1978 to 1980.

	Fork Length (mm)	Weight (gm)	Age	Egg Size (mm)	Gonad Weight (gm)	% Gonad Wt. of Body Wt.	Number of Eggs
	775	5423.0	9	1.7	377.1	7	93820
	777	5636.0	-	2.6	724.0	13	116725
	820	6666.0	10	2.0	624.0	9	143154
	824	6077.0	11	2.2	594.0	10	95699
	826	6900.0	9	2.3	1125.0	16	72282
	830	7114.0	0	2.2	599.0	8	116585
	845	-	9	2.5	1382.9	-	147639
	855	-	9	2.4	1430.3	-	164444
	866	-	9	2.4	1289.5	-	137818
Mean	824.2	6302.6	9.4	2.3	905.1	9.3	120907
SD[a]	31.3	692.2	0.8	0.3	400.2	4.9	29918
Range	775- 866	5423.0- 7114.0	9- 11	1.7- 2.6	377.1- 1430.3	7- 16	72282- 164444

[a] Standard Deviation

In the Slave River Delta, goldeye were among the most abundant of the larger fish taken, accounting for 18.3% (N = 881) of the total gillnet catch and 31.0% (N= 27) of the total beach seine catch. Less abundant overall than pike or walleye in the Slave River, and longnose sucker, burbot, or walleye in Resdelta Channel, goldeye were by far the most abundant fish gillnetted in the rest of the Delta (Table 16). Goldeye young-of-the-year and small juveniles were, on the other hand, relatively rare. In 1979, they represented only 0.4% (N= 18) and in 1980 only 0.7% (N = 54) of the total minnow seine catch. Catch per unit effort values during late spring, when young-of-the-year were most abundant, ranged from 1.4 per metre of shoreline seined (x 100) in early July 1979, to 2.5 per metre of shoreline seined (x 100) in late June, 1980.

Seasonal variations in gillnet and minnow seine catches of goldeye are shown in Figure 17. In 1978, gillnet catches were highest in mid-September then declined through October to early November. In 1979, catches were very low throughout June and then increased in early July, reaching a maximum in late August before again declining during the fall. Catches during the spring of 1980, unlike 1979, rose very quickly to a maximum shortly after break-up, declining slightly in early August. Reasons for the difference are unknown. Although possibly indicative of an early

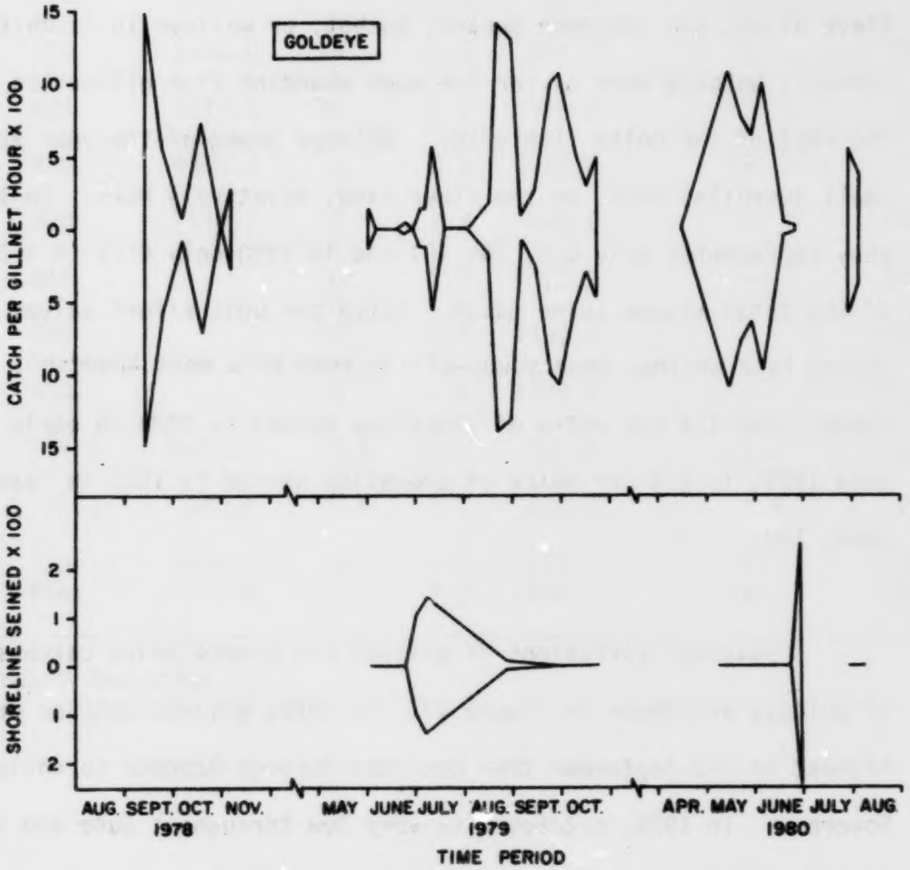

Figure 17. Seasonal patterns of catch per unit effort for goldeye taken in gillnets and minnow seines from the Slave River Delta, 1978 to 1980.

spawning period in 1980 as a result of breakup being earlier, the appearance of goldeye young-of-the-year in the Slave River Delta at the same time in both years suggests that the spawning period was also similar.

Donald and Kooyman (1977) describe goldeye populations in the Peace River moving into the Peace-Athabasca Delta during their spring spawning migration and, after spawning, returning to the Peace River. Part of the population, mainly large immature fish, continues migrating upstream on a summer feeding run. Later in the fall, they return to overwintering areas located downstream. Similar migrations are reported for goldeye in the Athabasca River (McCart er al. 1977; Bond 1980).

Goldeye populations in the Slave River Delta are thought to represent goldeye associated with the Peace-Athabasca Delta which, instead of moving upstream into the Peace or Athabasca rivers after spawning, move downstream into the Slave River toward the Slave River Delta. A goldeye, orginally tagged in the Peace-Athabasca Delta on July 30, 1976, and later recaptured in the Slave River Delta on September 24, 1979, supports this interpretation.

In October, goldeye presumably returned to overwintering areas located upstream since, during this period in 1979, declining catches in the Slave River Delta (0.11 to 0.03 fish per standard gillnet hour) coincided with high catches (1.05 fish per standard gillnet hour) at the base of rapids on the Slave River near Fort Smith. At this time, further movements past the rapids seemed unlikely although Nelson and Paetz (1972) consider them to be passable during the spring, high water period.

There is little to indicate that there is much, if any, goldeye spawning in the vicinity of the Slave River Delta. In 1979, catches were low throughout the spring spawning period and those that were captured showed no evidence of having recently completed spawning. In 1980, catches were much higher during the spring spawning period, but again, with the exception of one spent female taken on May 24, most fish did not show any evidence of spawning (Table 36). Most of the relatively small number of goldeye young-of-the-year taken in late June and early July are probably fish that drifted down from more important spawning areas upstream.

Goldeye captured in the Slave River Delta (excluding young-of-the-year) ranged from 93 to 419 mm fork length, (Figure 18) with 35% (N = 423) falling in the 280 to 299 mm range,

Table 36 The spawning condition of goldeye taken in the Slave River Delta, May 12 to June 28, 1980.
N = number of fish, G = green, R = ripe, SO = spawned out

	Males				Females				Water Temp.
Date	N	%G	%R	%SO	N	%G	%R	%SO	(°C)
May 12	1	100			1	100			8
15	1	100			2	100			10
16	1	100							11
17	1	100			3	100			11
18					1	100			12.5
22	1	100			1	100			13
24					3	66.7		33.3	13
29					1	100			12
June 2	1	100			2	100			11
10					1	100			14
11					1	100			15
12					1	100			16
14					1			100	15
28					2			100	19.5

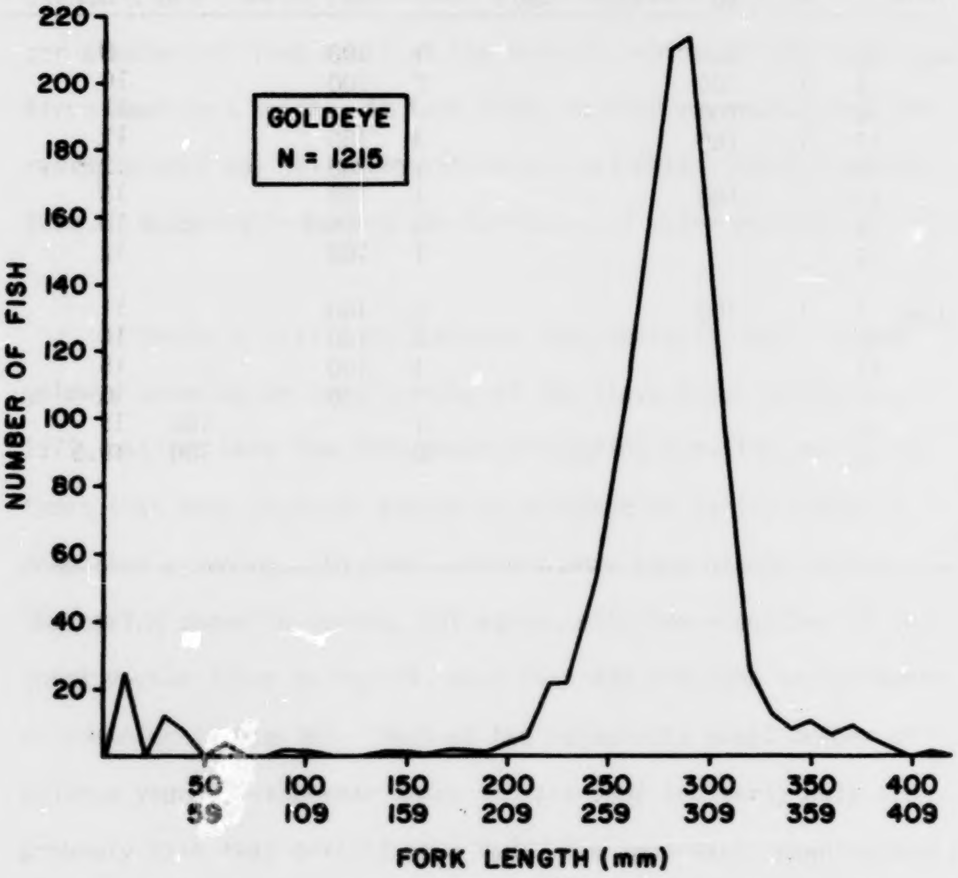

Figure 18. Length-frequency distribution of goldeye taken in the Slave River Delta, 1978 to 1980.

and 85% (N = 1035) in the 240 to 319 mm range. Relatively few goldeye were larger than 330 mm, or smaller than 219 mm.

The age-length relationships of 190 goldeye sampled from the Slave River Delta are presented in Table 37. The data were combined for males and females since significant differences in their age-length relationships could not be demonstrated. The sample was stratified by size to provide as complete a range as possible without sacrificing an excessive number of fish. It does not, therefore, represent the length or age frequencies of fish in the study area. A comparison of age-length relationships with the length-frequency distribution in Figure 18 suggests, however, that the age structure of goldeye in the Slave River Delta was dominated by 7 and 8 year old fish, most of which were taken in 1978 and 1979. The maximum recorded age was 23 years for a mature male 350 mm in fork length. The largest goldeye sampled was an 18 year old mature female, 390 mm in fork length.

A small percentage of goldeye in the Slave Delta are mature by age 5 (Table 37) and all are mature by age 9. Once mature, it appears that goldeye spawn every year since all fish age 9 or older contained sex products which would mature the following spring.

Table 37. Observed age-length relationship based on otoliths, age at maturity, and age-specific sex ratios of goldeye in the Slave Delta, 1978 to 1980.

Age	Fork Length (mm)			Males			Females			Unsexed	Total
	Mean	SD^a	Range	N	%	% Mature	N	%	% Mature		
0	67.0	2.7	64- 69	0	ND	ND	0	ND	ND	3	3
3	191.0	25.5	156-224	2	67	0	1	33	0	2	5
4	228.6	14.2	210-250	5	71	0	2	29	0	1	8
5	247.8	25.6	193-309	11	46	9	13	54	23	2	26
6	268.6	24.8	217-314	14	41	14	21	59	19	2	37
7	278.5	20.2	224-317	15	39	20	21	61	24	0	36
8	292.1	17.7	236-325	12	32	33	26	68	27	0	38
9	322.4	11.3	308-342	0	0	ND	8	100	88	0	8
11	337.0	18.5	323-358	1	33	100	2	67	100	0	3
12	330.3	16.5	318-354	1	25	100	3	75	100	0	4
13	373.0	ND	ND	0	0	ND	1	100	100	0	1
14	335.5	24.7	318-353	2	100	100	0	0	ND	0	2
15	335.0	ND	ND	1	100	100	0	0	ND	0	1
16	369.5	21.9	354-385	0	0	ND	2	100	100	0	2
17	361.0	15.1	349-378	1	33	100	2	67	100	0	3
18	380.6	29.8	376-390	0	0	ND	5	100	100	0	5
19	367.0	ND	ND	0	0	ND	1	100	100	0	1

Continued

Table 37. Concluded.

Age	Fork Length (mm)			Males			Females			Unsexed	Total
	Mean	SD	Range	N	%	% Mature	N	%	% Mature		
20	381.0	ND	ND	0	0	ND	1	100	100	0	1
21	373.3	5.1	369-379	1	33	100	2	67	100	0	3
22	368.0	ND	ND	0	0	ND	1	100	100	0	1
23	350.0	ND	ND	1	100	100	0	0	ND	0	1
Total				67	37	27	113	63	42	10	190

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a Standard Deviation

Figure 19 compares the growth rate of goldeye in the Slave Delta with those reported for goldeye in the Saskatchewan and Peace-Athabasca deltas. By comparison, goldeye in the Slave Delta grow more slowly and attain greater ages. It is, however, quite possible that the differences in growth are related to differences in aging techniques. While otoliths were used to age all goldeye in this study, scales were used in the others.

In 1979, goldeye young-of-the-year ranged from 8.5 mm on June 13 ($N = 1$), to 14.6 mm on July 2 ($N = 5$), 21.1 mm on July 7 ($N = 9$), and 62 mm on August 28 ($N = 1$). In 1980, goldeye young-of-the-year were 37.4 mm ($N = 19$) on August 1 to 4.

Length-weight relationships were calculated separately for male and female goldeye in the Slave Delta. Analysis of covariance did not, however, show any significant differences between either the slopes ($F = 0.447$) or intercepts ($F = 0.733$) of the two relationships. The data were therefore combined and the following relationships derived:

$$\mathrm{Log}_{10}\ \mathrm{Weight}\ (\mathrm{g}) = 3.123\ \mathrm{Log}_{10}\ \mathrm{Fork\ Length}\ (\mathrm{mm}) - 5.281$$

($N = 93$, length range 197-390 mm, $r = 0.987$, $P<0.05$).

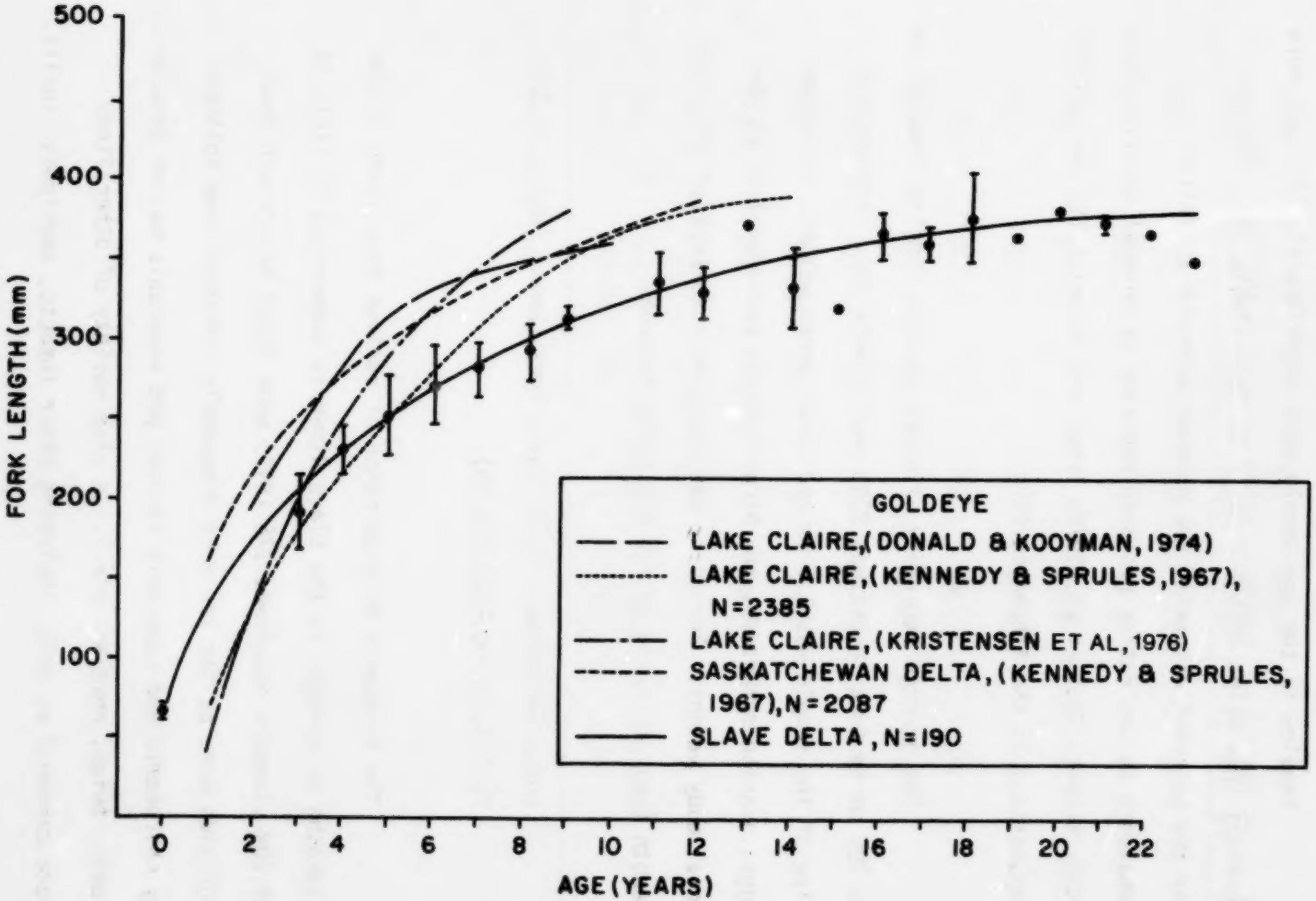

Figure 19. Comparison of the growth rate for goldeye in the Slave Delta with those in the Peace-Athabasca and Saskatchewan River Deltas. Points with vertical bars are mean fork lengths ±1 standard deviations. Single points are individual fish.

Females in the age sample were significantly ($P<0.05$) more abundant than males at age 8 ($x^2 = 11.756$) (Table 37). Reasons for the apparent disparity are unknown although a similar imbalance in sex ratios has been reported by several authors (Bond 1980; McCart, Tsui et al. 1978; Tripp and McCart 1979) for goldeye populations in the Athabasca River.

The average fecundity of eight goldeye ranging from 302 mm to 385 mm in fork length was 9205 eggs (Table 38). Average egg size of the sample was 1.6 mm and total gonad weight, including eggs, ovarian membranes, and blood vessels averaged 7.3% of the total body weight. Fecundity was positively correlated with fork length (mm) according to the following formula:

$$\text{Log}_{10}\ \text{Fecundity} = 6.591\ \text{Log}_{10}\ \text{Fork Length (mm)} - 12.830$$
$$(N = 8,\ r = 0.890,\ P<0.05).$$

The frequency of occurrence of various food items in the stomachs of goldeye in the Slave River is summarized in Table 39. Of 209 stomachs examined, 176 (84%) were found to contain food. Corixids were by far the most frequently consumed item followed by chironomid and caddisfly larvae, and vegetable matter (poplar seeds, twigs, needles, etc.). A wide variety of other items were consumed as well, including other insects, amphipods, snails,

Table 38. Egg counts from goldeye taken in the Slave Delta, 1978 and 1979.

	Fork Length (mm)	Weight (gm)	Age	Egg Size (mm)	Gonad Weight (gm)	% Gonad Wt. of Body Wt.	Number of Eggs
	302	320.1	7	1.6	7.7	2	1999
	303	323.3	8	1.5	14.6	5	3351
	318	678.0	-	1.7	19.8	6	5562
	337	537.0	-	1.5	47.4	9	12783
	355	501.0	-	1.6	49.1	10	8256
	378	562.6	18	1.7	42.4	8	10500
	379	678.0	18	1.7	62.3	9	14847
	385	589.7	16	1.7	50.8	9	16345
Mean	344.6	523.7	13.4	1.6	36.8	7.3	9205
SD[a]	34.5	139.3	5.5	0.1	19.9	2.7	5313
Range	302-385	320.1-678.0	7-18	1.5-1.7	7.7-62.3	2-10	1999-16345

a Standard Deviation

Table 39 Frequency of occurrence of food items in stomachs of goldeye sampled in the study area, 1978 to 1980.

Food Item	N	%
Crustacea		
Malacostraca		
Amphipoda	1	0.7
Insecta		
Ephemeroptera	3	2
Coleoptera	10	6
Hemiptera		
Corixidae	130	74
Trichoptera	22	12
Diptera		
Unidentified larva	1	0.7
Tipulidae	2	1
Chironomidae	23	13
Insect remains	11	6
Mollusca		
Unidentified	3	2
Fish		
Longnose sucker	1	0.7
Fish remains	9	5
Rodent remains	1	1
Fur pellets	9	6
Vegetable matter	18	10
Digested matter	41	23
Number of stomachs containing food	176	
Number of empty stomachs	33	
Number of stomachs examined	209	

fish, rodents, and fur pellets. The diet of young-of-the-year goldeye presented earlier in Table 20, was dominated by chironomid larvae (86% of all stomachs found to contain food, N = 21) and corixids (76% of all stomachs containing food). Other items included mayfly larvae, stonefly nymphs, midge adults, and butterfly larvae.

5. Northern Pike:

The norhtern pike (*Esox lucius*) has a circumpolar distribution, ranging. in North America, from Labrador to Alaska. In addition to their value as sport fish, they are also important as a commercial and domestic fish species. Their biology in northern Canada has been extensively reviewed by Millar and Kennedy (1948), McPhail and Lindsey (1970); Hatfield et al. (1972), Stein et al. (1973), Jessop et al. (1973), Slaney (1974, 1975), and Percy (1975); in Alaska by Alt (1969), Cheney (1972), and Craig and Wells (1975).

Northern pike were, overall, the most abundant fish taken in gillnets, accounting for 19.9% (N = 960) of the total gillnet catch in the Slave River Delta. Average catch per gillnet hour (x100) was 5.1, or approximately one pike in a 24 hour gillnet set. The highest catches were recorded in the Slave River (9.35 pike per gillnet hour x 100), followed by, in decreasing order, Nagle Channel (3.42), Resdelta Channel (2.28), Steamboat Channel (1.17), East Channel (0.99), and Middle Channel (0.46).

Young-of-the-year pike, when present, were also widely distributed throughout the Delta although, unlike larger pike, they were most abundant in the central areas of the Delta, including East Channel, Middle Channel, and most of the minor channels. Seasonal variations in minnow seine catches of pike young-of-the-year also show that they are present during late summer and fall (Figure 20) only, and explains, in part, why very few young-of-the-year were captured during the 1980 studies which ended in early August.

Seasonal changes in gillnet catches of pike (Figure 20) were irregular in 1979, but generally showed an increase in abundance from spring to fall. Presumably this represented a gradual downstream movement during the open water period to feeding and overwintering areas in the Slave River Delta or Great Slave Lake. There was no indication of pike spawning in the Delta (Table 40) itself, and it was therefore assumed that pike had moved to warmer spawning areas located upstream, before the lower Slave River had cleared itself of ice in late May. Indirect evidence from the seasonal abundance of young-of-the-year supported the above interpretation since it suggested that

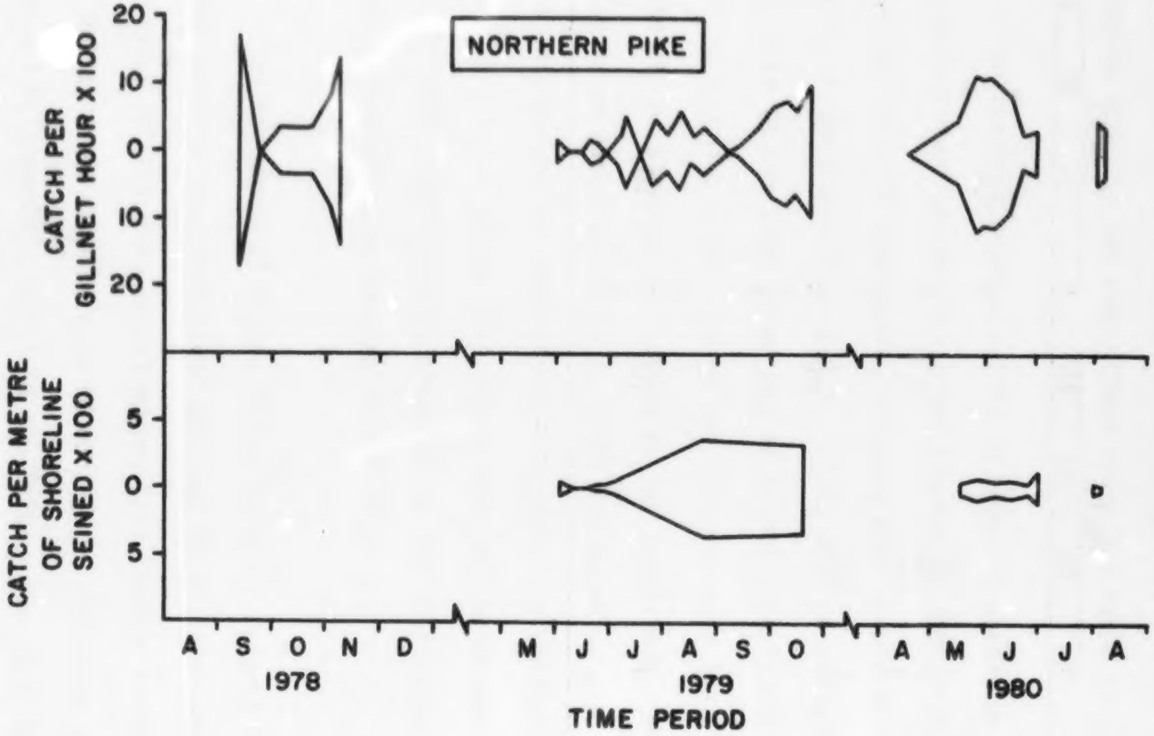

Figure 20. Seasonal patterns of catch per unit effort for northern pike taken in gillnets and minnow seines in the Slave River Delta, 1978 to 1980

Table 40. The spawning condition of northern pike taken in the Slave River Delta and the Salt River, May 31 to July 11, 1979. N=number of fish, G=green, R=ripe, SO=spawned out.

Date	MALES				FEMALES				Water Temp. (°C)
	N	%G	%R	%SO	N	%G	%R	%SO	
Slave Delta									
May 31					2	100			
June 12	1	100							12.8
June 18	1	100			2			100	15.6
June 24	1	100							17.0
June 25					1			100	17.2
June 29	1	100							18.9
July 6	1			100	4			100	20.6
July 10					1			100	21.7
July 11					6			100	21.7
Salt River									
June 14					2			100	17.0
June 16	1			100	1	100			17.0
June 17					2			100	-

young-of-the-year were migrating downstream late in the summer to rearing areas in the lower Slave River and Slave River Delta.

Unlike 1979, northern pike in spawning condition were relatively common during the spring studies in 1980 (Table 41), suggesting that, in some years, spawning also occurs in the vicinity of the Slave River Delta. It is also possible that, first, pike in the Slave River may be fairly opportunistic in selecting spawning areas, and second, the distance the pike migrate may be strongly influenced by ice conditions. When breakup is as early as it was in 1980, for example, pike may not have to migrate as far upstream as in years like 1979 when breakup is delayed beyond the normal spawning period for northern pike. In 1980, peak spawning appeared to extend from May 4 to May 26, at temperatures ranging from 5 to 14°C.

The movements of tagged fish (Table 42) suggest that northern pike in the Slave River drainage do not undertake extensive migrations. Of 264 pike tagged during fall studies in the Slave River Delta, seven were recaptured during the following spring, summer and fall periods, still in the Delta. Two were recaptured outside the Delta, one in Resolution Bay just to the west of the Delta, and one in the Little Buffalo, a tributary of Resolution Bay. Two of 19 pike tagged in the Slave River at Fort Smith,

Table 41. The spawning condition of northern pike taken in the Slave River Delta, April 15 to June 30, 1980. N=number of fish, G=green, R=ripe, SO=spawned out.

	Males				Females				Water Temp. (°C)
Date	N	%G	%R	%SO	N	%G	%R	%SO	
April 15	1	100							0
May 4					3		100		7
9					3		100		5
10	1		100		1	100			10
11					1		100		8
12					1		100		9
13	1		100		2		100		10
15					3	100			11
17	4		100		3	66.7	33.3		11
18	6	33.3	50	16.7	3	66.7			11
20	4		75	25	3	66.7		33.3	11.5
21	7	14.3	71.4	14.3	5	60	20	20	13
22	9	33.3	55.6	11.1	9	66.7		33.3	13
23	5		100		9	44.4	11.1	44.4	13
24	6		66.7	33.3	9	55.6	11.1	33.3	13.5
25	3	33.3	66.7		2	50		50	14
26	6	16.7	33.3	50	3	33.3	33.3	33.3	12
28	2	50	50		1		100		12
29	7	57.1	42.9		6	33.3	66.7		12
30					3	66.7	33.3		10
June 1	1		100						11
2	1	100			5	100			11
3	2	50	50		3	66.7	33.3		11
4	1	100			2	50	50		12
5	1			100	2	50	50		12
6	4	100			3	100			12
7	1	100			2	50		50	13
8					2		100		14
10	1	100							14
11	2	50	50						15
12	7	71.4	28.6		5	40	20	40	16
14	1			100	1			100	15
17	2			100	1			100	16
19					1			100	17
20	4			100	1			100	17.5
21	1			100					17.5
22	1			100	1			100	17.5

(continued)

Table 41 Concluded

	Males				Females				Water Temp. (°C)
Date	N	%G	%R	%SO	N	%G	%R	%SO	
June 23	1			100					18.5
27					1			100	19.5
28	1			100					19.5
29	4			100	3		66.7	33.3	20
30	1			100	1			100	

Table 42 Summary of northern pike recaptures

Date Tagged	Tagging Location	Date Recaptured	Recapture Location
September 18, 1978	Slave River Delta	August 28, 1979	Slave River Delta
September 29, 1978	"	October 17, 1979	"
October 6, 1978	"	September 21, 1979	"
October 6, 1978	"	September 24, 1979; May 9, 1980	"
October 11, 1978	"	October 5, 1979	"
October 13, 1978	"	August 2, 1979	"
September 29, 1979	"	April, 1980	"
September 29, 1979	"	September, 1980	Little Buffalo River
October 5, 1979	"	June, 1980	Resolution Bay
October 8, 1979	Slave River, Fort Smith	September, 1980	Slave River, Fort Smith
October 9, 1979	"	June, 1980	"

October 4 to October 10, 1979, were recaptured in the same location during the following spring and summer.

Pike captured in the Slave River Delta ranged from 8.5 mm total length for recently emerged young-of-the-year to 998 mm fork length for mature fish (Figure 21). Most (65%) of the sample fell in the 360 to 659 mm range with a secondary peak in the 60 to 209 mm range. The modal length for both males and females fell in the 390 to 539 mm range although females predominated in the larger size classes.

Age-length data for northern pike captured during the study period in the Slave River Delta are presented in Table 43. Pike in this sample ranged from 0 to 15 years of age and from 134 to 998 mm in fork length. Few fish exceeded 8 years of age or a fork length of 670 mm. Generally the oldest and largest fish were females, although, because of the small sample sizes, no significant differences could be demonstrated.

Females reach maturity as early as the end of their first full year of age (i.e. in the spring of their second summer). Most are mature by age 3 and all are mature by age 8. Males generally mature at an earlier age and all were mature by age 6. It appears that, once mature, pike spawn every year.

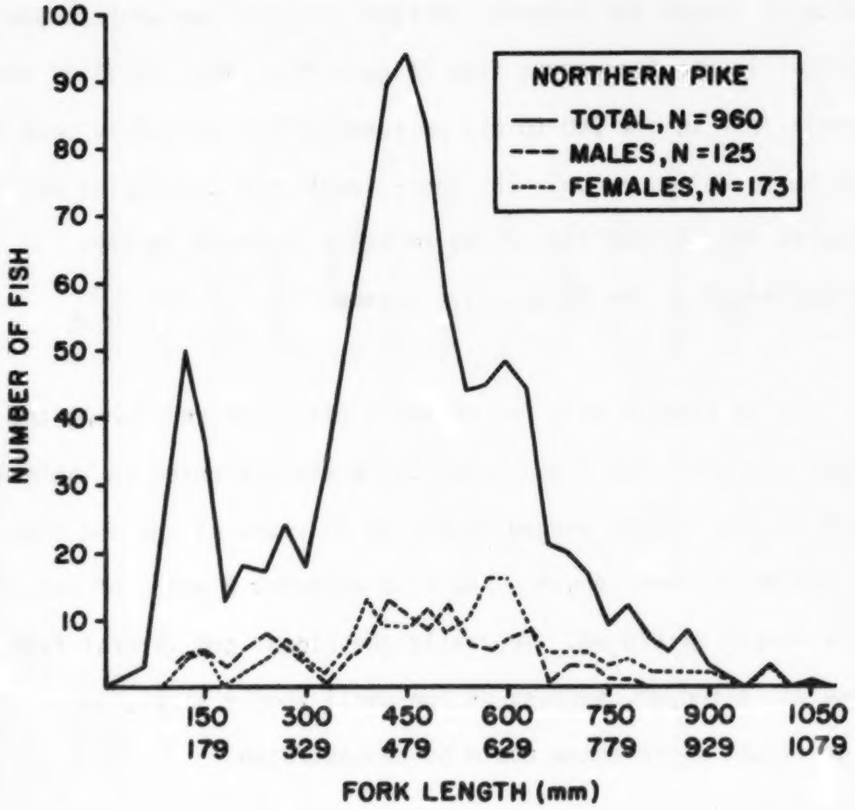

Figure 21. Length-frequency distribution of northern pike taken in the Slave River Delta, 1978 to 1980.

Table 43. Observed age-length relationship based on scales, age at maturity, and age-specific sex ratios of northern pike in the Slave Delta, 1978 to 1980.

	Fork Length (mm)			Males			Females				
Age	Mean	SD[a]	Range	N	%	% Mature	N	%	% Mature	Unsexed	Total
0	152.0	12.7	134-174	0	ND[b]	ND	0	ND	ND	11	11
1	221.9	27.6	168-272	9	75	0	3	25	33	7	19
2	272.3	29.7	218-345	9	41	0	13	59	0	5	27
3	394.5	65.5	267-492	12	57	75	9	43	78	0	21
4	439.4	51.4	351-550	10	40	80	15	60	93	0	25
5	514.6	65.3	413-631	3	13	67	20	87	75	0	23
6	553.9	56.7	396-665	10	34	100	19	66	95	0	29
7	610.7	59.6	477-766	5	20	100	20	80	90	0	25
8	646.9	58.1	570-769	4	21	100	15	79	100	0	19
9	723.0	63.0	600-780	2	29	100	5	71	100	0	7
10	710.7	47.3	630-772	3	50	100	3	50	100	0	6
11	804.3	99.2	639-920	1	20	100	4	80	100	2	7
12	823.3	43.7	782-882	1	25	100	3	75	100	0	4
13	782.0	173.9	659-905	1	50	100	1	50	100	0	2
14	936	ND	ND	0	0	ND	1	100	100	0	1
15	994.0	4.0	990-998	0	0	ND	3	100	100	0	3
Total				70	30	66	164	70	84	25	259

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[a] Standard Deviation

[b] No Data

Pike in the Athabasca River (Bond 1980) grow at a faster rate than those in the Slave Delta but do not attain as great an age or size (Figure 22). Growth rates were similar in the Slave Delta, the Kakisa River (a tributary of Great Slave Lake), the Rabbitskin River (a tributary of the Mackenzie River), the Mackenzie River, and the Christina River (a tributary of the Athabasca River). In Lake Athabasca, growth was slower than elsewhere but fish attained a greater age and size.

In 1979, young-of-the-year pike in the Slave River Delta, had mean lengths of 8.5 mm (N = 1) on June 18, 30.0 mm (N = 1) on July 1, 77.5 mm (N= 4) on July 8, 122.1 mm (N = 18) in August , and 137.3 mm (N = 8) on October 13.

Using analysis of covariance, no significant differences could be demonstrated between the length-weight relationships of male and female pike in the Slave Delta (F slopes = 0.003, F intercepts = 1.400). The relationship for the combined samples, based on six randomly selected fish from each 30 mm size class, was:

$$\text{Log}_{10}\text{ Weight (g)} = 3.139\ \text{Log}_{10}\text{ Fork Length (mm)} - 5.506$$

(N = 119, length range 209-998 mm, $r = 0.995$, $P<0.05$).

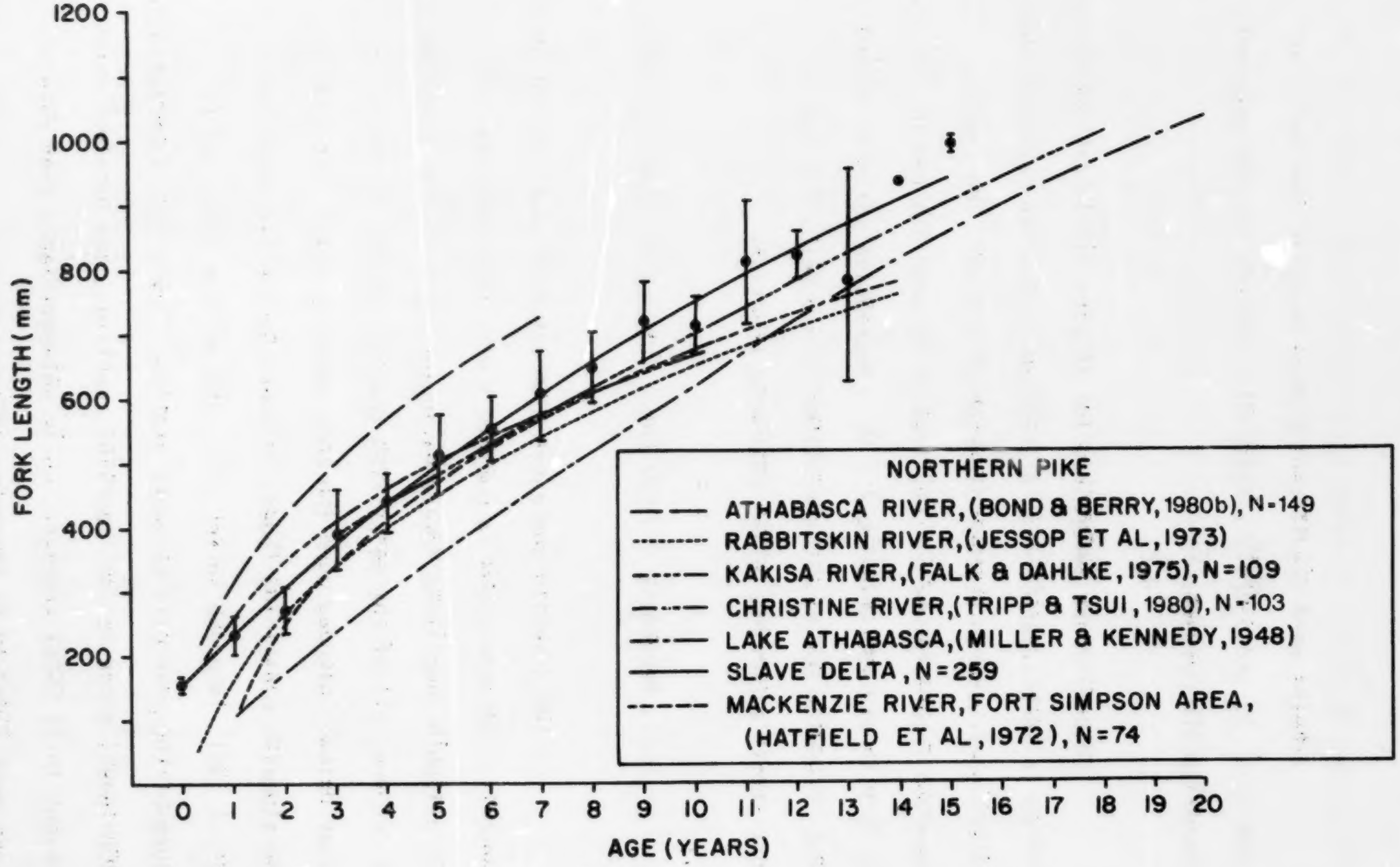

Figure 22. Comparison of the growth rate of northern pike in the Slave River with six other populations in the MacKenzie Basin. Points with vertical lines are mean fork lengths ±1 standard deviation. Single points are individual fish.

Females were significantly more abundant than males at ages 5, 7, 8, and overall (Table 43). Reasons for the apparent disparity are unknown.

Fecundity was determined for 18 pike (Table 44) averaging 576 mm in fork length (range 411-920 mm). Average fecundity was 41 589 eggs with an average diameter of 1.4 mm. The highest recorded fecundity was 214 600 from an 11 year old female, 920 mm in fork length and weighing 7.1 kg. Regression analysis showed that fecundity was highly correlated ($r = 0.9618$, $P<0.05$) to fork length according to the following equation:

$$\text{Log}_{10}\ \text{Fecundity} = 3.722\ \text{Log}_{10}\ \text{Fork Length (mm)} = 5.838.$$

Of 189 juvenile and adult pike stomachs examined for food contents, 104 were found to contain food. Fish were the only recognizable food items recorded, including, with the exception of inconnu, all of the major fish species present in the Slave River Delta. Ciscoes were the most commonly eaten fish (34% of the stomachs containing food), followed by smaller pike (11%), burbot (9%), longnose sucker (7%), and walleye (6%). Of 66 young-of-the-year pike stomachs examined (Table 20), invertebrates (amphipods, midge larvae, mayflies, corixids, and beetles) were present in 41 (62%) stomachs, while unidentifiable fish remains alone were found in 25 stomachs (38%).

Table 44. Egg counts from northern pike taken in the Slave Delta, 1978 and 1979.

	Fork Length (mm)	Weight (gm)	Age	Egg Size (mm)	Gonad Weight (gm)	% Gonad Wt. of Body Wt.	Number of Eggs
	411	580.0	3	1.2	26.6	5	17754
	412	475.1	3	1.5	22.2	5	7079
	416	615.9	4	-	12.6	2	8300
	420	602.5	4	1.4	24.3	4	7286
	428	683.3	6	1.2	24.6	4	10513
	442	597.3	4	1.4	21.7	4	9992
	492	1008.0	3	1.5	33.9	3	10841
	493	954.4	4	1.5	33.9	4	11467
	508	1001.5	5	1.1	18.8	2	17169
	510	1047.0	5	1.4	33.6	3	15180
	588	2021.0	5	1.5	75.7	4	22928
	635	1640.0	6	-	37.4	2	46380
	692	3130.0	9	1.6	36.9	4	56980
	710	2560.8	8	1.0	43.8	2	41833
	710	3117.0	8	1.4	98.8	3	54069
	766	3922.7	7	1.5	178.7	5	99745
	810	4897.1	-	1.8	302.1	6	96480
	920	7112.5	11	1.5	448.5	6	214600
Mean	575.7	1998.1	5.6	1.4	81.9	3.8	41589
SD[a]	158.9	1832.6	2.3	0.2	116.5	1.3	52156
Range	411- 920	475.1- 7112.5	3- 11	1.1- 1.8	12.6- 448.5	2- 6	7097 214600

[a] Standard Deviation

6. Flathead Chub:

The North American distribution of the flathead chub (*Platygobio gracilis*) is restricted to the Great Plains, though it occurs as far north as the Mackenzie Delta. Large, turbid rivers like the Slave River are the preferred habitat of this species.

In the Slave River Delta, flathead chub were widely distributed in all major and minor channels, reaching their greatest numbers in Resdelta Channel and the Slave River, and their lowest in Nagle Channel. Overall, they accounted for 4.3% (N = 209) of the total gillnet catch, and 4.8% (N = 552) of the total minnow seine catch.

Seasonal variations in gillnet catches of flathead chub (Figure 23) were generally too irregular to support any definite conclusions about their seasonal movements. They tended to be abundant shortly after spring breakup, but numbers declined soon after. Later in the summer, they become more abundant and then disappear again in late fall as they leave the Delta, possibly to overwintering areas located in Great Slave Lake.

In 1979, small flathead chub taken in minnow seines were abundant in the spring and early summer, declined in late summer

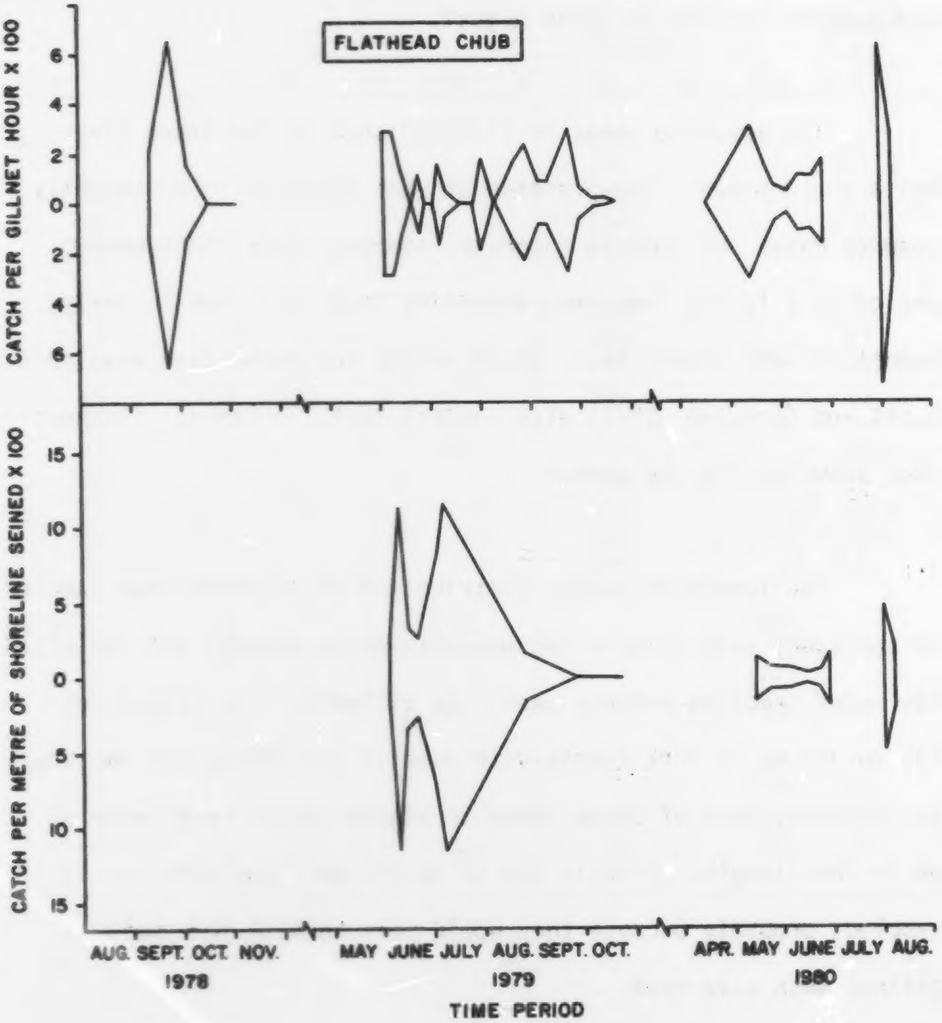

Figure 23. Seasonal patterns of catch per unit effort for flathead chub taken in gillnets and minnow seines in the Slave River Delta, 1978 to 1980.

and, by fall, had completely disappeared. In 1980, catches were low throughout the spring study period, May 12 to June 30, and moderately high in early August.

The spawning areas of flathead chub in the Slave River Delta are unknown. The presence of what appeared to be recently spawned males and females suggests, however, that the spawning period is a fairly long one, extending from late June to early August in 1980 (Table 45). Based on the scattered data available, Scott and Crossman (1973) also suggest that, in Canada, flathead chub spawn during the summer.

The length-frequency distribution of flathead chub sampled in the study area (Figure 24) was distinctly bimodal and reflected the major sampling methods used. In gillnets, fish ranged from 133 to 345 mm in fork length with most in the 250 to 299 mm range. In contrast, most of those taken in minnow seines were under 50 mm in fork length. Fish in the 50 to 219 mm range were rarely sampled, probably because they would pass through the smallest gillnet mesh size used.

Age-length data based on otoliths for 58 flathead chubs in the Slave River Delta are presented in Table 46. Fish in the sample ranged from 4 to 14 years in age and from 133 to 137 mm in

Table 45. The spawning condition of flathead chub taken in the Slave River Delta, May 17 to August 6, 1980. N = number of fish, G = green, R = ripe, SO = spawned out.

	Males				Females				Water Temp.
Date	N	%G	%R	%SO	N	%G	%R	%SO	(°C)
May 17					2	100			11
21					1	100			11.5
24					1	100			13
26					1	100			14
29					1	100			12
June 1					3	100			11
7					1	100			13
11					2	100			15
14	1	100			2	100			15
22					1			100	
23	1			100					18
26					2	50		50	19
27					1	100			19.5
28					4	100			19.5
29					1	100			20
July 10	3			100	3			100	-
19	1			100					-
30					7			100	-
31	1			100	4			100	19
Aug 2					11			100	19
3					1			100	19
5					1			100	20
6	2	50		50	4	25		75	19

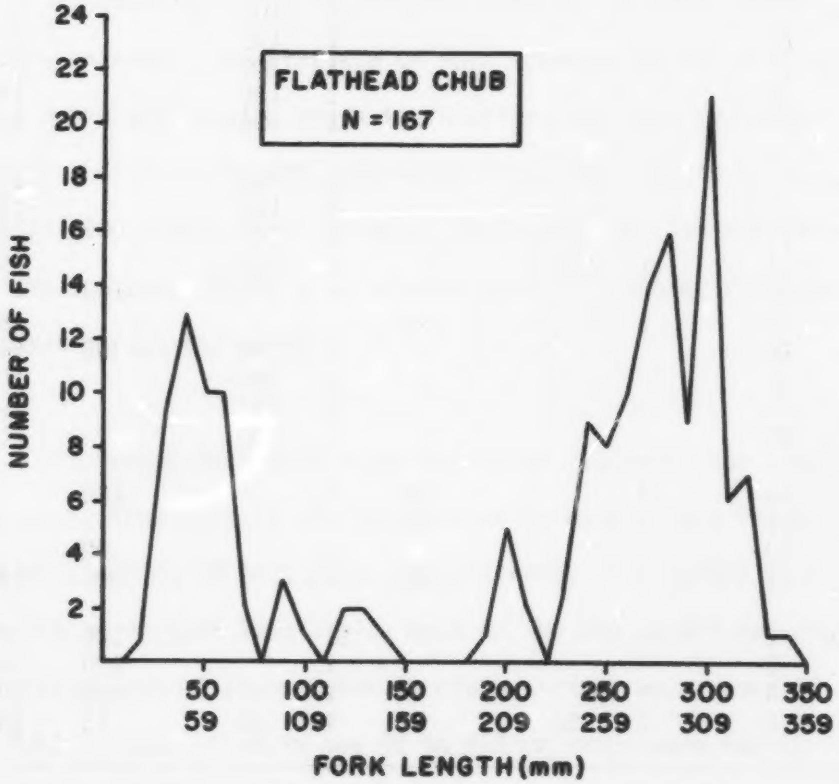

Figure 24. Length-frequency distribution for flathead chub taken in the Slave River Delta, 1978 to 1980.

Table 46. Observed age-length relationship based on otoliths, age at maturity, and age-specific sex ratios of flathead chub in the Slave Delta, 1978 to 1980.

Age	Fork Length (mm)			Males			Females			Unsexed	Total
	Mean	SD[a]	Range	N	%	% Mature	N	%	% Mature		
4	181.7	42.2	133-208	0	0	ND[b]	1	100	0	2	3
5	198.0	67.9	150-246	1	50	100	1	50	100	0	2
6	242.3	27.1	214-268	0	0	ND	2	100	100	1	3
7	247.5	11.4	234-262	2	33	50	4	67	75	0	6
8	277.3	22.3	249-308	0	0	ND	9	100	100	0	9
9	288.6	14.2	275-322	0	0	ND	9	100	100	0	9
10	285.8	18.2	256-309	0	0	ND	12	100	100	0	12
11	302.7	18.7	287-327	0	0	ND	4	100	100	0	4
12	314.0	20.1	300-337	0	0	ND	3	100	100	0	3
13	303.7	11.9	287-315	0	0	ND	4	100	100	0	4
14	299.0	14.4	287-315	0	0	ND	3	100	100	0	3
Total				3	6	33	52	94	96	3	58

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a Standard Deviation

b No Data

fork length. Females reach maturity as early as age 5 and once mature, appear to spawn every year. Males were rarely sampled. Of the 58 flathead chub sampled by detailed dissection, 52 were females (Table 46). Similar sex ratios favouring females have been reported in the Athabasca (McCart et al. 1977; Bond 1980) and Mackenzie (Hatfield et al. 1972) rivers.

The growth of flathead chub in the Slave River Delta (Figure 25) was very similar to that reported for flathead chub in the Athabasca River (McCart et al. 1977), but considerably faster than that reported for flathead chub in the Mackenzie River (Hatfield et al. 1972; Stein et al. 1973). The latter, however, mention the possibility that errors could have resulted from difficulties in reading crowded annuli on the scales of older fish.

The data were insufficient for a comparison of the length-weight relationships of males and females. The relationship for a combined sample of male and female flathead chub in the Slave Delta was:

$$\text{Log}_{10}\ \text{Weight (g)} = 3.131\ \text{Log}_{10}\ \text{Fork Length (mm)} - 5.2673$$

($N = 27$, length range 140-322 mm, $r = 0.9645$, $P<0.05$).

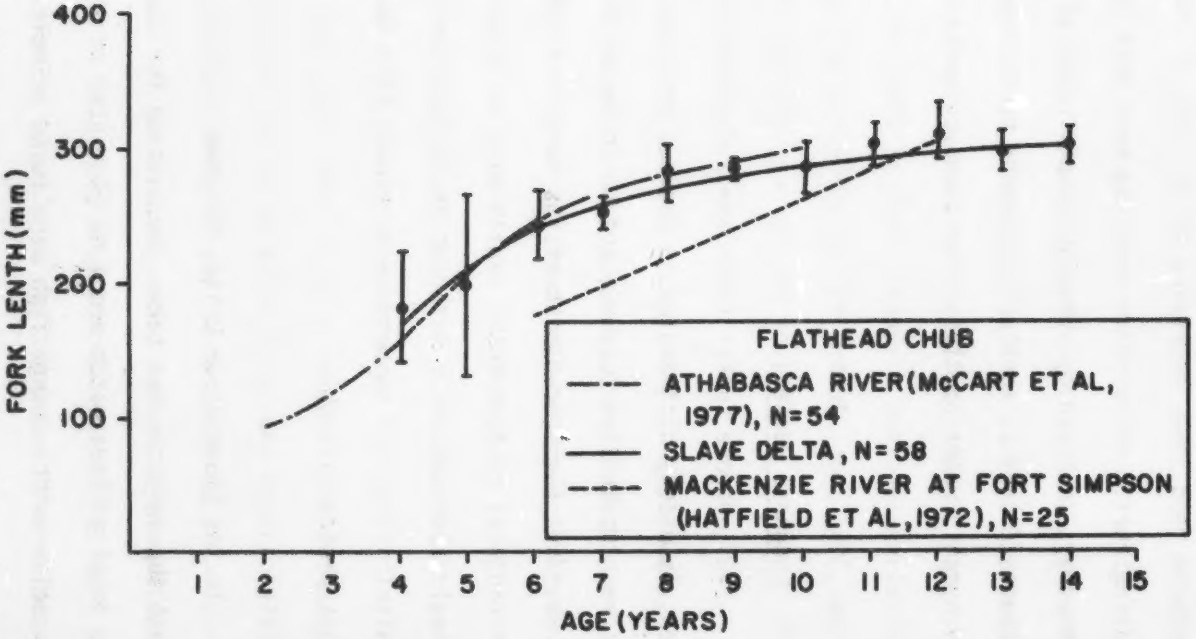

Figure 25. Comparison of the growth rate for flathead chub in the Slave Delta with those in the Athabasca and MacKenzie Rivers. Points with vertical lines are mean fork lengths ±1 standard deviation. Single points are individual fish.

Of 88 flathead chub stomachs examined, 53 (60%) were found to contain food. Corixids were by far the most frequently encountered food item, occurring in 14 (26%) of the stomachs containing food. Chironomids were the next most common food item (7 stomachs), followed by stonefly nymphs, caddisfly larvae, ceratopogonid larvae, snails (2 stomachs each), and ostracods, mayfly nymphs, water beetles, clams, and oligachaetes (1 stomach each).

7. Longnose Sucker:

The longnose sucker (*Catostomus catostomus*), a spring spawner, is widely distributed in Canada, from New Brunswick and Quebec west to British Columbia and north to the Beaufort Sea. It is abundant throughout most of its range and appears to tolerate a wide range of environmental variables. In general, though, it is a cool water species. Although it is occasionally marketed as "mullet", its main importance to man is as a forage species for more desirable fish.

In the Slave River Delta, longnose suckers were one of the most abundant species taken, accounting for 11.7% (N = 564) of the total gillnet catch and 4.4% (N = 511) of the total minnow seine catch. Large fish were found principally in Resdelta Channel and the Slave River, while young-of-the-year and yearling fish were more evenly distributed, reaching their greatest abundance in minor channels and their lowest in Nagle Channel.

In 1979, fish susceptible to capture in gillnets increased in abundance from early June to a peak in late June and early July, before declining through the summer to the middle of September (Figure 26). A secondary peak occurred, in 1978, in late September, and, in 1980, in late October. Seasonal variations in gillnet catches from early May to the end of June, 1980, were similar to those for the same period in 1979.

The first peaks in late June (1980) or early July (1979) are thought to represent a post spawning downstream migration from spawning areas located upstream. In both years, most of the fish taken at this time were either spent fish or fish that were classified as green but showed evidence of reabsorbing their eggs (Table 47 and 48). Water temperatures (15 to 21°C) also tended to be higher than those usually recorded during longnose sucker spawning elsewhere (9 to 15°C; Tripp and McCart 1979). The second peak in late fall likely corresponds to a downstream movement to overwintering areas by fish which stayed upstream during the summer. Very similar patterns of movement have been described for longnose suckers in the Athabasca River (Bond and Berry 1980 a, b; Bond 1980; Jones et al. 1978; Tripp and McCart 1979).

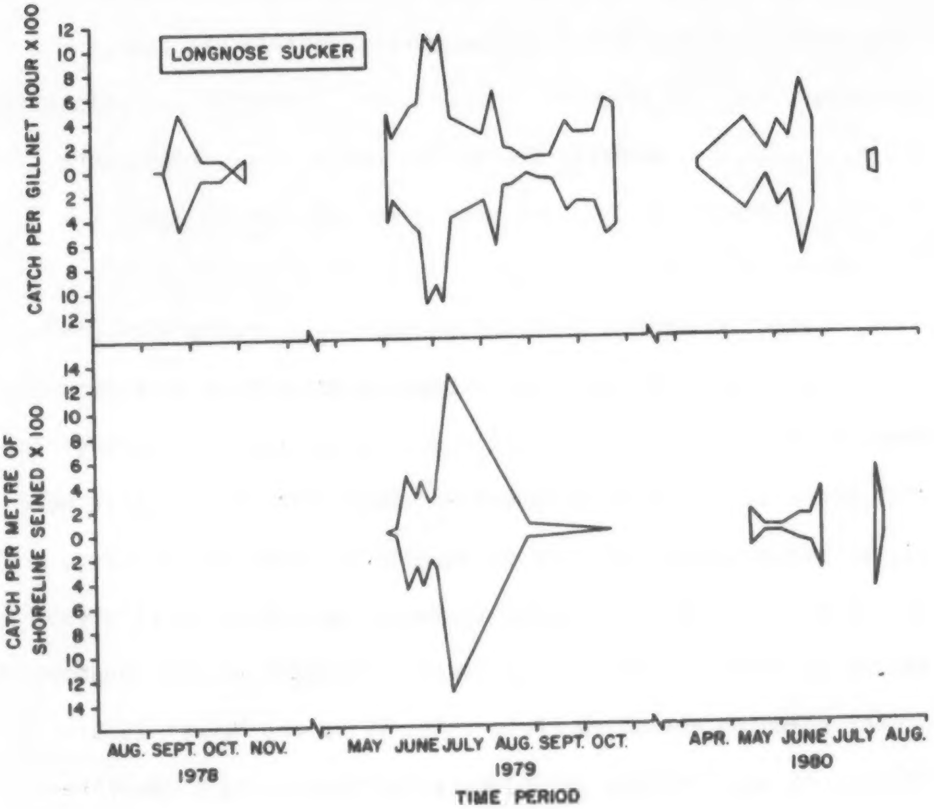

Figure 26. Seasonal patterns of catch per unit effort for longnose suckers taken in gillnets and minnow seines from the Slave River Delta, 1978 to 1980.

Table 47. The spawning condition of longnose suckers taken in the Slave River Delta and the Salt River, May 29 to July 11, 1979. N=number of fish, G=green, R=ripe, SO=spawned out.

	MALES				FEMALES				Water Temp.
Date	N	%G	%R	%SO	N	%G	%R	%SO	(°C)
Slave Delta									
June 7	1		100						11.7
June 10	2			100					12.2
June 13	1		100		1			100	12.8
June 14	2		50	50	1	100			13.3
June 19					1			100	16.1
June 20	1			100	2	100			16.1
June 21	2	50		50	1			100	ND[a]
June 23	4	75		25	1	100			16.7
June 25	1			100	1			100	17.2
June 29	5			100	5	80		20	18.9
July 2	10			100	5	100			19.2
July 4					1	100			20.0
July 6	4	100			7	100			20.6
July 10	2	50		50					21.7
July 11	2			100	3			100	21.7
Salt River									
May 29					1	100			ND
May 30	4	100							ND
May 31	6	66.6	33.3		2	100			9.5
June 12	6	16.7	33.3	50	6	50		50	ND
June 13	4			100	3	33.3		66.6	ND
June 14					1	100			17
June 16	1			100	1			100	17

a No Data

Table 48. Spawning condition of longnose suckers in the Slave River Delta, April 14 to June 29, 1980. N = number of fish, G = green, R = ripe, SO = spawned out.

	Males				Females				Water Temp.
Date	N	%G	%R	%SO	N	%G	%R	%SO	(°C)
April 14					1	100			ND
20	1	100							ND
22					1	100			ND
24					1	100			ND
May 10					4	100			5
17	2		100		2	100			11
18	1		100		2	100			11
20	1		100						11
21	3	66.7	33.3						11.5
22	1		100						13
23	3		100						13
24	3		100						13
25	2	50	50		1	100			13.5
30	1		100						10
June 2	3		100						11
3	1		100						11
11					1	100			15
14	1		100						15
15	1			100	2	50		50	16
17	2			100	4	100			16
18	2			100					17
19	2			100	3	66.7		33.3	17
20					2	50		50	17.5
22	1			100	2			100	18
27	1			100					19.5
28	2			100	1	100			19.5
29					1			100	20

ND No Data

The movements of tagged longnose suckers are similar to those described above and also suggest that longnose suckers in the Slave River belong to populations which inhabit Great Slave Lake. Of 483 longnose suckers tagged during a post-spawning downstream migration in the Salt River near Fort Smith, June 13 to June 17, 1979, three were subsequently recaptured in Great Slave Lake, the first five miles north of Hay River (October 26, 1979), the second 10 miles north of Hay River (August 5, 1980), and the third near Simpson Islands (August 30, 1980). One tagged October 7, 1979 in the Delta was recovered late in October in Resolution Bay. Another tagged October 10, 1979 in the Slave River at Fort Smith was also recovered in Resolution Bay, September, 1980.

Seasonal variations in minnow seine catches of longnose suckers are shown in Figure 26. In both 1979 and 1980, catches through May and June were low and largely composed of yearling fish. In 1979, young-of-the-year averaging 23.9 mm (N=30) in fork length suddenly appeared and catches peaked in early July. Catches dropped thereafter, and by October, small longnose suckers were rarely taken in the study area. In 1980, young-of-the-year probably moved into the Delta after the spring studies were terminated.

There is no evidence to indicate that longnose suckers spawn in the Slave River Delta. As mentioned earlier, longnose suckers spawn in early spring, shortly after spring breakup at temperatures ranging from 9 to 15°C. Coarse gravels, absent in the study area, are the preferred substrate for spawning. In addition, most of the longnose suckers captured in the study area during the spring spawning period were either spent or non-spawning fish. Young-of-the-year were not taken until early July when they had already grown to an appreciable size and had probably drifted downstream from spawning areas farther upstream. Likely spawning areas include the rapids on the Slave River near Fort Smith and various tributaries such as the Salt River where large numbers of spent longnose suckers were observed moving downstream during the period June 12 to 17, 1979.

The length-frequency distribution of longnose suckers (excluding those taken in minnow seines) captured in the Slave River Delta is presented in Figure 27. Longnose suckers ranged from 105 to 574 mm in fork length with most (62%) in the 400 to 519 mm range. The modal length was 480-489 mm while juvenile longnose suckers in the 100 to 359 mm range were rarely captured. While this may be the result of sampling bias, it is also possible that juvenile longnose suckers have a distribution quite different from that of the adult segment of the population.

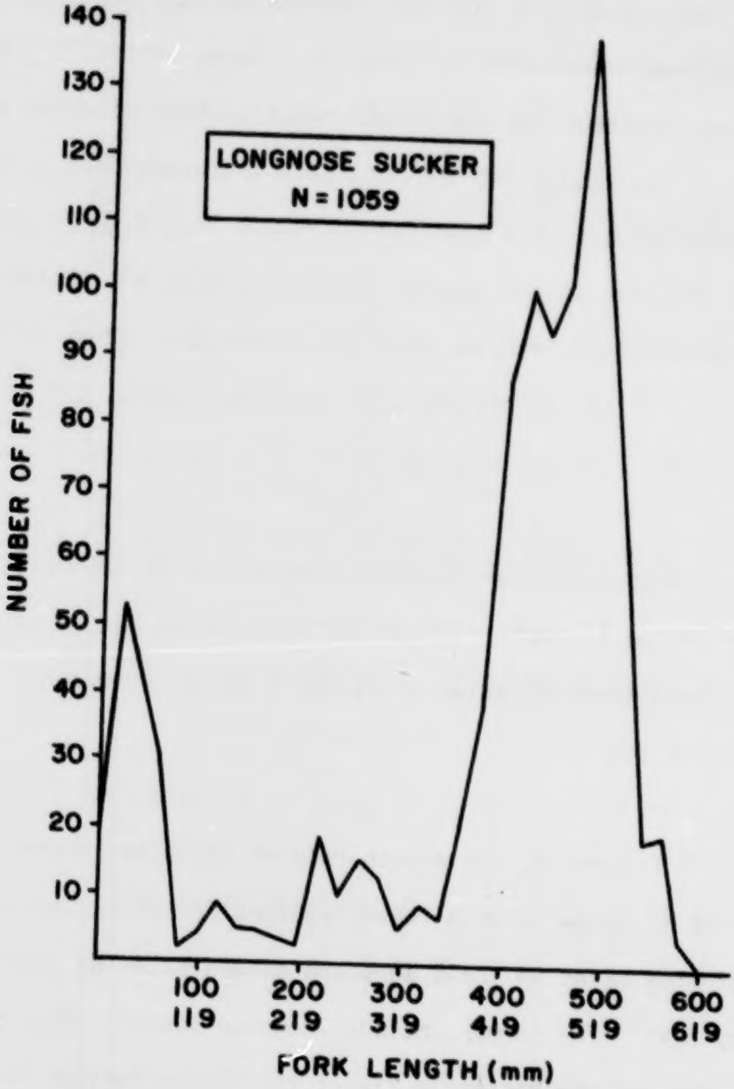

Figure 27. Length-frequency distribution of longnose suckers in the Slave Delta, 1978 to 1980.

Age-length data for 166 longnose suckers captured in the Slave Delta are presented in Table 49. There were no significant differences between the age-length relationships of males and females in the sample and the data have therefore been combined. Longnose suckers in the aged sample ranged from 2 to 28 years of age but few fish in the sample, especially females, exceeded 16 years. The oldest fish was a 28 year old male, 502 mm in fork length, while the largest was a 14 year old female, 574 mm in fork length.

The youngest age at which females reached maturity was 8 years and by 12 years all were mature. Males mature earlier, the youngest reaching maturity at age 6 and all reaching maturity by age 10.

In Figure 28, the growth rate of longnose suckers in the Delta is compared with those reported for other locations, some of them based on scale ages and others based on otolith or fin ray ages. The former include longnose suckers from Great Slave Lake and the Mackenzie River; the latter include longnose suckers from the Donnelly River, a tributary of the Mackenzie River, and the Athabasca River (Figure 28).

Table 49. Observed age-length relationship based on otoliths, age at maturity, and age-specific sex ratios of longnose suckers in the Slave Delta, 1978 to 1980.

Age	Fork Length (mm)			Males			Females			Unsexed	Total
	Mean	SD[a]	Range	N	%	% Mature	N	%	% Mature		
2	107.5	3.5	105-110	0	ND[b]	ND	0	ND	ND	2	2
3	137.7	27.2	109-167	0	ND	ND	0	ND	ND	4	4
4	184.8	27.3	162-230	0	ND	ND	0	ND	ND	5	5
5	229.9	27.1	186-268	2	25	0	6	75	0	1	9
6	263.3	20.8	235-293	5	38	20	8	62	0	3	16
7	273.9	20.2	228-314	11	58	0	8	42	0	2	21
8	350.3	32.1	277-408	6	37	50	10	62	40	1	17
9	396.7	35.9	314-448	8	53	100	7	47	86	1	16
10	411.1	37.0	356-483	4	31	75	9	69	78	0	13
11	423.9	33.1	378-503	5	33	100	10	67	90	0	15
12	433.5	23.7	401-468	5	50	100	5	50	100	1	11
13	439.3	36.6	381-490	6	60	100	4	40	100	0	10
14	463.8	57.1	413-574	1	17	100	5	83	100	0	6
15	485.8	26.7	459-533	3	50	100	3	50	100	0	6
17	512.7	37.7	473-548	1	33	100	2	67	100	0	3
18	500.5	41.7	471-530	0	0	ND	2	100	100	0	2
19	478.7	23.7	464-506	3	100	100	0	0	ND	0	3

Continued

Table 49.   Concluded

Age	Fork Length (mm)			Males			Females			Unsexed	Total
	Mean	SD	Range	N	%	% Mature	N	%	% Mature		
21	519.7	52.6	469-570	2	50	100	2	50	100	0	4
23	482.0	ND	ND	1	100	100	0	0	ND	0	1
26	502.0	ND	ND	1	100	100	0	0	ND	0	1
28	502.0	ND	ND	1	100	100	0	0	ND	0	1
Total				65	45	68	81	55	61	20	166

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a Standard Deviation

b No Data

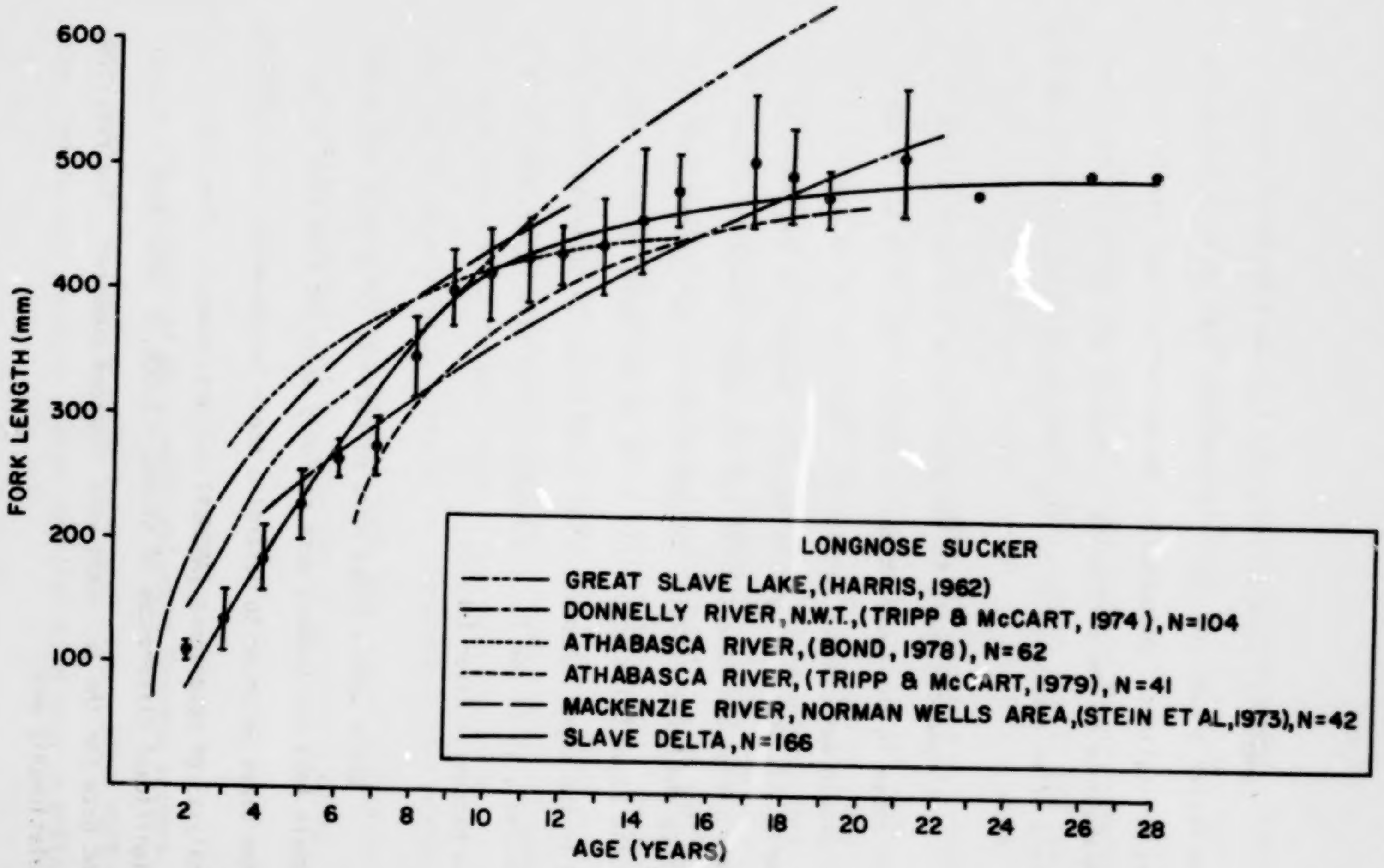

Figure 28. Comparison of the growth rate for longnose suckers in the Slave Delta with five other populations in the MacKenzie Basin. Points with vertical lines are mean fork lengths ±1 standard deviation. Single points are individual fish.

Generally, populations whose ages were based on scales show faster growth and lower maximum ages than those based on fin rays or otoliths. Undoubtedly, the differences are partly attributable to the difficulty in reading the scales of aged fish, a fact often commented on by the individuals using the scale method.

Longnose suckers in the Slave Delta grew more slowly than those in the lower Athabasca River (Bond 1974) up to age 8 but growth was similar thereafter. Both populations were, however, faster growing than longnose suckers in the Donnelly River (Tripp and McCart 1974) and the upper Athabasca River (Tripp and McCart 1979). Maximum recorded ages ranged from 28 in the Slave Delta (otoliths) to 22 in the Donnelly River (otoliths), 20 in the upper Athabasca River (otoliths), 19 in Great Slave Lake (scales), 15 in the lower Athabasca River (fin rays), and 12 in the Mackenzie River (scales).

Where sample sizes were sufficient, three male and three female longnose suckers were randomly selected from each 10 mm size class in order to determine their length-weight relationships. Analysis of covariance (ANCOVA) did not, however, show any significant differences (F slopes = 0.006, F intercepts = 0.160) and data for the two sexes were therfore combined. The resulting relationship was:

$\log_{10}$ Weight (g) = 3.035 $\log_{10}$ Fork Length (mm) - 5.020
(N = 125, length range 228-548 mm, $r = 0.990$, $P<0.05$)

The average fecundity of eight longnose suckers sampled from the Slave River Delta was 47 269, ranging from 23 558 for a 12 year old female 417 mm in fork length, to 68 545 for an 18 year old female 530 mm in length (Table 50). Total gonad weight including eggs, ovarian membranes and blood vessels averaged 9.7±1.7% of the total body weight. Using regression analysis, no significant differences could be demonstrated between fork length and fecundity in the above sample ($r = 0.565$, $P>0.05$). Part of this observed variability is attributed to fish that had failed to spawn and were starting to absorb their eggs. Others were noted to have up to three distinct egg sizes. Since only eggs of the largest size class were enumerated, the actual number of eggs likely to be spawned may have been underestimated. Reasons for eggs being absorbed or for the presence of several egg sizes are largely unknown, although they may be related to a slow maturation rate and/or a shortage of suitable spawning areas.

The stomachs of 80 juvenile and adult longnose suckers were examined for food contents in the laboratory. Since most of the stomachs were, however, taken from fish found dead in gillnets,

Table 50. Egg counts from longnose suckers taken in the Slave River Delta, 1979 and 1980.

	Fork Length (mm)	Weight (g)	Age	Egg Size (mm)	Gonad Weight (g)	% Gonad Wt. of Body Wt.	Number of Eggs
	417	845	12	1.6	83.5	10	23 558
	418	995	11	1.8	87.6	9	25 711
	426	931	11	1.5	76.6	8	67 831
	452	1033	13	1.6	78.4	8	46 099
	468	1291	12	1.8	148.4	12	45 173
	517	1803	17	1.8	199.4	11	50 070
	530	1609	18	1.5	126.1	8	68 545
	570	1659	21	1.5	202.2	12	51 168
Mean	475	1271	14.4	1.63	125.3	9.7	47 269
SD[a]	57.8	373.8	3.8	0.14	53.0	1.7	16 610
Range	417-570	845-1659	10-21	1.5-1.8	76.6-202.2	8-12	23 558-68 545

---

a Standard Deviation

the stomach contents were often in an advanced state of decomposition. The enumeration of food items was therefore biased toward empty stomachs or items which were resistant to digestion. Sixty-four percent of the stomachs examined were in fact empty. The most frequently encountered items in stomachs containing food were unidentifiably digested matter (79% of the stomachs containing food, N = 29), followed by chironomid larvae (17%), copepods (14%), and corixids (3%).

In 21 young-of-the-year and yearling longnose sucker stomachs found to contain food, chironomid larvae was found in 13, fingernail clams and snails in 3, and oligochaetes, amphipods, copepods, and fish eggs in 1. Corixids, an important component of many other small species (Table 20), were absent probably because suckers are bottom feeders.

8. Burbot:

Burbot (*Lota lota*), a late fall to mid-winter spawner, is widely distributed across Canada, absent only from Nova Scotia and the Atlantic Islands, the Atlantic and Pacific coasts, and the Arctic Islands. While it is not a commercially exploited species, large numbers of burbot are taken, as they are in the Slave Delta, for domestic use.

Burbot accounted for 15.1% of the total gillnet catch in the Slave River Delta, most of them taken in the lower Slave River and Resdelta Channel. As with most of the larger species, gillnet catches of burbot in the rest of the Delta were low throughout the study period (Table 16).

In 1979, young-of-the-year burbot were common in the Slave River Delta, particularly during the spring. Major concentrations were located in the central portions of the Delta including East Channel, Middle Channel, Old Steamboat Channel, and most of the minor side channels. They were rarely taken in Resdelta or Nagle Channels (Table 18). In 1980, young-of-the-year burbot had a similar distribution, although they were less abundant (0.5 per 100 metres of shoreline seined) than in 1979 (3.3 per 100 metres of shoreline seined).

Patterns of seasonal variation in catches of burbot in gillnets, set lines, and minnow seines are presented in Figure 29. As indicated, a moderate number of burbot were captured by gillnets and set lines early in the year. Catches soon declined, however, and remained low for most of the open water period before peaking in late October and early November. After freeze up, burbot continue to concentrate in the Slave Delta and lower Slave River, presumably spawning, until the end of December. After

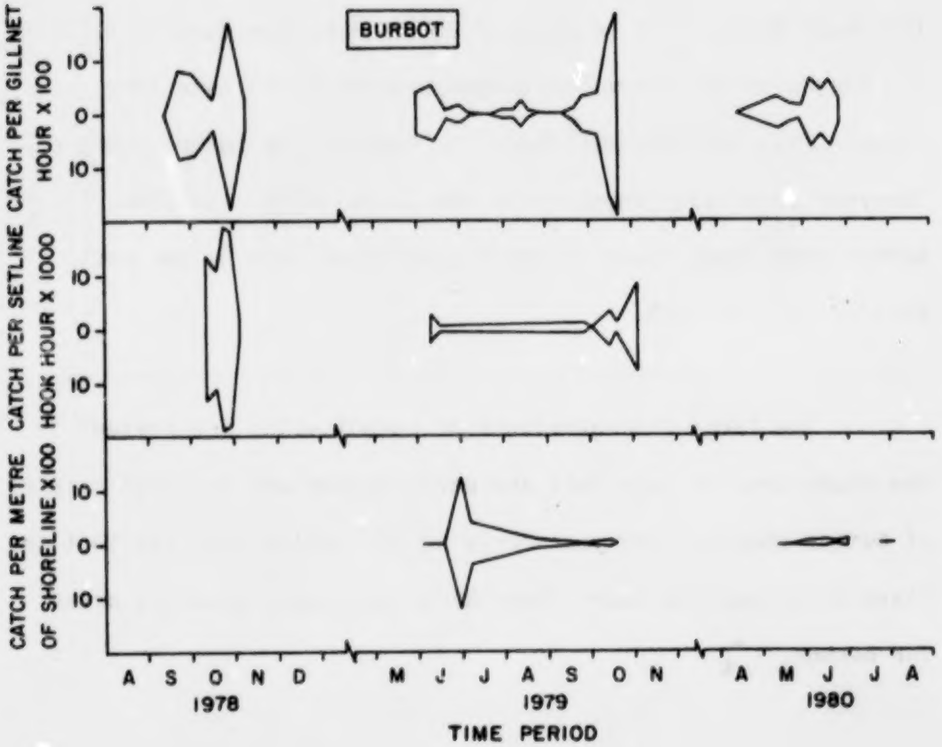

Figure 29. Seasonal patterns of catch per unit effort for burbot taken with gillnets, set lines, and minnow seines in the Slave River Delta, 1978 to 1980.

December, domestic catches of burbot decline and fishing is discontinued. A single burbot tagged in the Slave River Delta on October 29, 1978, was recaptured upstream on the Salt River the following spring, May 30, 1979, suggesting that some burbot migrate upstream and overwinter in the Slave River.

Young-of-the-year were first taken in drift samples from the lower Slave River on June 18 and peaked from June 27 to July 1. Minnow seine catches of burbot peaked at the same time (Figure 29), but soon declined. By August, few burbot young-of-the-year were taken anywhere in the Slave Delta. In 1980, burbot were first taken in drift samples on June 5, two weeks earlier than in 1979.

The large concentrations of burbot which are present in the study area in late fall and early winter and the high catches of burbot young-of-the-year early in the spring indicate that the Slave Delta and the lower Slave River are major spawning areas for burbot.

In 1978, no ripe females and only two ripe males were taken during the study period (Table 51). In 1979, spawning was apparently earlier since all fish taken after November 1 were in ripe spawning condition. Freeze up occurred on November 7.

Table 51. The spawning condition of burbot taken in the Slave River Delta, October 26 to November 9, 1978 and October 17 to November 5, 1979. N=number of fish, G=green, R=ripe, SO=spawned out.

	MALES				FEMALES				Water Temp. (°C)
Date	N	%G	%R	%SO	N	%G	%R	%SO	
1978									
Oct. 26	1	100							2.2
Oct. 28					1	100			2.2
Oct. 29	7	85.7	14.3		2	100			2.2
Oct. 30	1		100		1	100			1.7
Oct. 31	17	100			5	100			1.7
Nov. 3	13	100			3	100			1.1
Nov. 6					1	100			0.6
Nov. 9	1	100			1	100			0
1979									
Oct. 17					1	100			6.0
Oct. 19	2	100							5.5
Oct. 20	3	100							5.5
Oct. 22	1	100							5.0
Nov. 1	1		100		2		100		ND[a]
Nov. 2					3		100		ND
Nov. 3	5		100		6		100		ND
Nov. 4	2		100		3		100		ND
Nov. 5	2		100		5		100		ND

[a] No Data

Aquarium observations of burbot spawning indicate that burbot prefer to spawn over sandy substrates (Fabricius 1954, *in* Chen 1969), a common substrate in deeper areas of the Slave Delta. The spawning period of burbot in the Slave River Delta appears, however, to be considerably earlier than that reported for burbot in other areas, possibly because of earlier freeze up. Spawning times for burbot in other areas were late March to April in Lake Erie (Clemens 1950), December to February in Wyoming (Bjorn 1940), late January in Lake Simcoe (MacCrimmon 1959), and early February in Lake Winnipeg (Hewson 1955).

The length-frequency distribution of burbot sampled in the study area is presented in Figure 30. They ranged in total length from 7.0 mm for recently emerged young-of-the-year to 1019 mm, with most (58%) in the 360 to 509 mm range. The modal length for males fell in the 390 to 419 mm range while females were more abundant in larger size classes. The modal length for young-of-the-year fell in the 0 to 29 mm size class.

The age-length relationship of 143 burbot sampled in the study area is presented in Table 52. Although females were consistently larger than males, no significant ($P<0.05$) differences between the lengths of males and females could be demonstrated at any age, largely because of the small sample sizes for older age

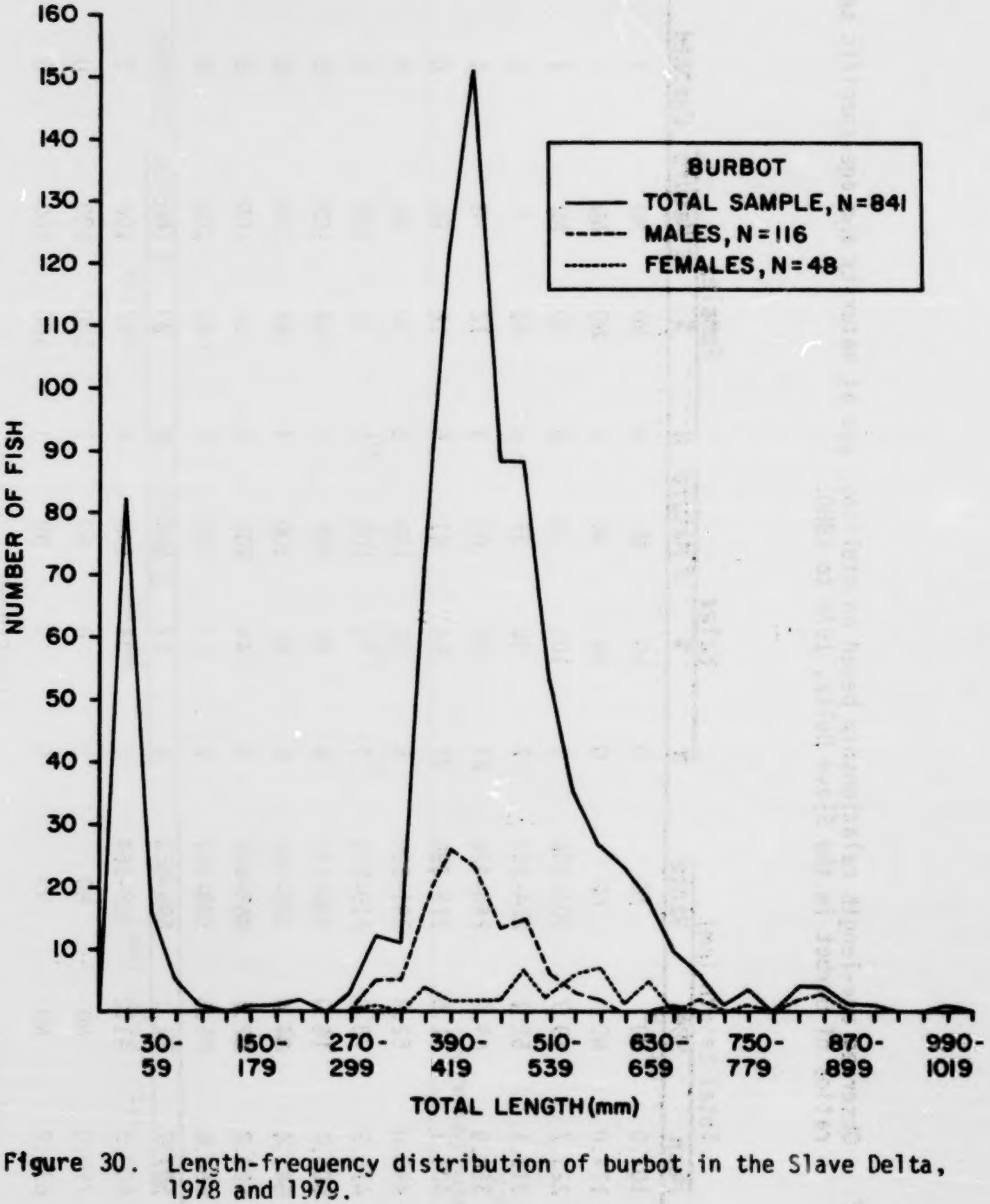

Figure 30. Length-frequency distribution of burbot in the Slave Delta, 1978 and 1979.

Table 52. Observed age-length relationship based on otoliths, age at maturity and age-specific sex ratios of burbot in the Slave Delta, 1978 to 1980.

	Total Length (mm)			Males			Females				
Age	Mean	SD[a]	Range	N	%	% Mature	N	%	% Mature	Unsexed	Total
1	107.0	ND[b]	ND	0	ND	ND	0	ND	ND	1	1
2	174.0	ND	ND	0	ND	ND	0	ND	ND	1	1
3	223.7	19.7	201-236	1	100	0	0	ND	ND	2	3
4	311.1	52.1	224-393	7	58	57	5	42	0	3	15
5	358.9	49.9	246-428	22	88	83	3	12	0	1	26
6	406.1	41.5	315-490	27	84	81	5	16	60	0	32
7	458.6	52.5	391-520	5	50	100	5	50	80	0	10
8	475.3	73.0	419-579	3	75	100	1	25	100	0	4
9	506.7	19.9	486-540	6	86	100	1	14	100	0	7
10	541.4	34.4	485-588	5	56	100	4	44	100	0	9
11	529.2	62.1	458-655	4	44	100	5	56	100	0	9
12	568.0	75.6	503-707	1	17	100	5	83	100	0	6
13	597.7	72.1	505-663	1	17	100	5	83	100	0	6
14	600.2	41.2	558-664	2	33	100	4	67	100	0	6
15	750.0	ND	ND	0	0	ND	1	100	100	0	1
16	635.0	ND	ND	0	0	ND	1	100	100	0	1

Continued

Table 52. Concluded.

Age	Total Length (mm)			Males			Females			Unsexed	Total
	Mean	SD	Range	N	%	% Mature	N	%	% Mature		
17	850.0	ND	ND	0	0	ND	1	100	100	0	1
18	758.0	85.2	660-842	1	25	100	3	75	100	0	4
19	850.0	ND	ND	0	0	ND	1	100	100	0	1
20	820.0	ND	ND	0	0	ND	1	100	100	0	1
Total				85	63	84	50	27	76	8	143

a Standard Deviation

b No Data

classes. Fish in the aged sample ranged from 1 to 20 years in age and from 107 to 842 mm in total length. Females reach first maturity at age 6 and by age 8 all females are mature. Males mature earlier, at age 4, and all males are mature by age 7. Once mature, burbot apparently spawn every year.

In Figure 31 the growth rate of burbot in the Slave Delta is compared with the growth rate of four other populations. The upward inflection in the growth rate of fish older than 14 in the Slave Delta represents a bias toward faster growing females which dominated the older age classes. A similar bias is shown in the curves for burbot in the Tanana and Yukon rivers.

The growth rate of burbot in the four northern populations is similar up to age 5 but diverges in older fish. Of the four populations, fish in the Mackenzie River grow fastest after age 5 while those in the Slave Delta grow slowest. Maximum age and size are, however, similar in all four populations. The southern population in Lake Simcoe, Ontario, grows fastest of all but does not appear to live as long.

The mean lengths of samples of young-of-the-year burbot in the Slave Delta ranged from 7.3 mm (N = 12) on June 20 to 28.4 mm (N = 30) on July 7, 61.0 mm (N = 3) on August 26, and

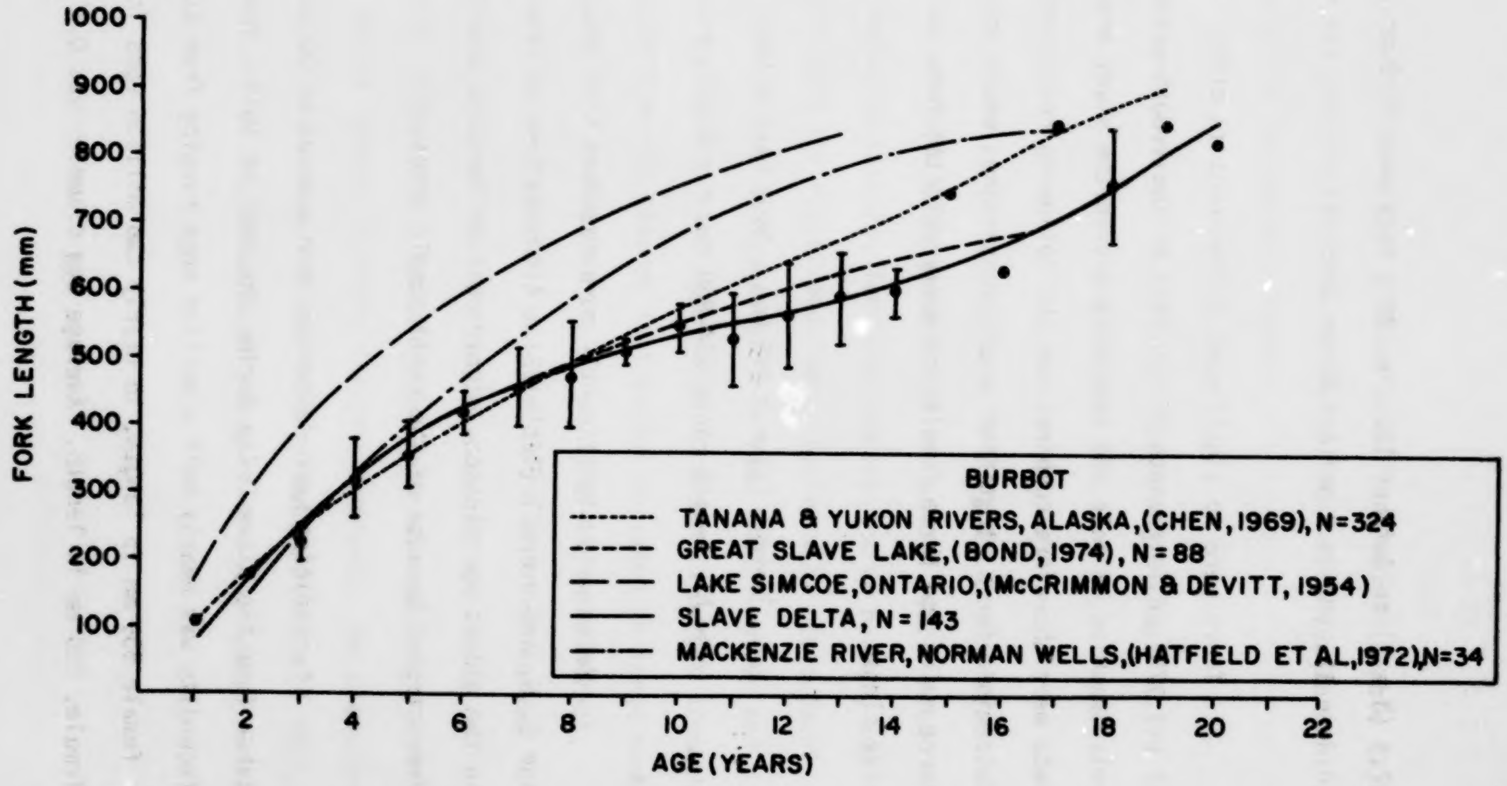

Figure 31. Comparison of the growth rate for burbot in the Slave Delta with those in Alaska, the Mackenzie River, Great Slave Lake and Lake Simcoe, Ontario. Points with vertical lines are mean body lengths ±1 standard deviation. Single points are individual fish.

92.5 (N = 3) on October 13. In 1980, they were 22.9 mm (N = 18) on June 12, and 24.8 mm (N = 6) on June 27.

There were no significant differences in either the slopes (F = 3.175) or intercepts (F = 0.792) of the length-weight relationships of male and female burbot in the study area. The data were therefore combined and the following relationship determined for a stratified sample consisting, where possible, of three males and three females randomly selected from each 30 mm size class:

$$\text{Log}_{10}\ \text{Weight (g)} = 3.046\ \text{Log}_{10}\ \text{Body Length (mm)} - 5.324$$

(N = 77, length range 234-850 mm, $r = 0.986$, $P<0.05$).

Males were significantly more abundant than females at age 5, 6, and overall (Table 52). Although females predominated in the oldest age classes, significant differences could not be demonstrated because of the small sample sizes.

Fecundities were determined for a total of 20 burbot taken from the Slave Delta during the fall of 1978. The average fecundity was nearly half a million eggs ranging from 116 000 for a female 539 mm in length, to nearly two million eggs for a large female, 850 mm in length. Average egg diameter was 0.7 mm while total gonad weight averaged 5.5% of total body weight (Table 53). Fecundity was positively correlated with total body length (mm) according to the following formula:

$$\mathrm{Log}_{10}\ \mathrm{Fecundity} = 3.496\ \mathrm{Log}_{10}\ \mathrm{Body\ Length\ (mm)} - 4.199$$

$(N = 20,\ r = 0.894,\ P<0.05)$.

A total of 77 adult and juvenile burbot stomachs were examined, of which 50 (85%) were found to contain food. Fish remains, including ciscoes, longnose suckers, other burbot, and sticklebacks were the major food items, followed by occassional caddisfly larvae, corixids, cranefly larvae, midge larvae, and amphipods. Mysids and fish eggs which occurred in burbot stomachs probably came from the ciscoes that burbot consumed in large numbers during the fall. The food habits of young-of-the-year burbot, presented earlier in Table 20, were dominated by midge larvae which occurred in 27 of the 31 stomachs examined and found to contain food. Other items included, in order of importance, copepods, mayfly larvae, stonefly larvae, amphipods, and cladocerans. Corixids, a major component in the diet of most other small fish, were never found in the stomachs of young-of-the-year burbot.

Table 53. Egg counts from burbot taken in Slave River Delta, 1978 and 1979.

	Total Length (mm)	Weight (gm)	Age	Egg Size (mm)	Gonad Weight (gm)	% Gonad Wt. of Body Wt.	Number of Eggs
	498	636.8	7	0.6	33.8	5	225574
	503	942.0	12	0.7	66.7	7	223789
	504	1018.4	10	0.8	57.1	6	164897
	510	856.2	7	0.7	70.6	8	315483
	535	1180.0	-	0.5	56.9	5	170624
	539	913.7	12	0.7	32.2	4	116021
	544	907.2	11	0.8	42.2	5	242703
	545	1183.0	11	0.7	77.1	7	300700
	546	1328.5	12	0.7	71.6	5	264775
	549	1267.0	10	0.6	55.2	4	264007
	588	1351.6	10	0.7	83.4	6	249748
	633	1537.0	13	0.6	69.9	5	269309
	635	1716.0	16	0.7	109.8	6	254141
	655	2128.5	11	0.7	85.5	4	349962
	707	2272.5	12	0.8	153.8	7	804327
	715	2334.0	18	0.6	135.2	6	768049
	815	4307.1	18	-	56.2	6	1047703
	842	3221.1	18	0.7	186.7	6	726774
	850	5835.0	17	0.6	192.6	3	1034779
	850	7146.0	19	0.6	424.0	6	1979125
Mean	628.1	2104.1	12.8	0.7	113.0	5.5	488624
SD[a]	125.8	1757.0	3.8	0.1	94.3	1.2	456341
Range	498- 850	636.8- 7146.0	7- 19	0.5- 0.8	32.2- 424.0	3- 8	116021 1979125

[a] Standard Deviation

9. Walleye:

The walleye (*Stizostedion vitreum*) is widely distributed in eastern Canada and the prairies. In the Mackenzie River drainage, its range extends as far north as the Beaufort Sea. This species is actively sought by both commercial and sport fishermen and is, overall, probably the most economically valuable freshwater fish in Canada (Scott and Crossman 1973). Large turbid lakes and rivers, like the Slave River, are its preferred habitat.

On the Slave River Delta, the walleye was one of the most abundant large fish species present, accounting for 18.5% (N = 891) of the total gillnet catch. By far the largest concentrations were taken in Resdelta Channel and the lower Slave River where catches were, on the average, five to six times greater than those elsewhere. Young-of-the-year and small juvenile walleye were rarely sampled, indicating that the Delta is not a major rearing area.

The seasonal variation in gillnet catches of walleye (Figure 32), together with the results of tagging studies (Table 54) indicate that there are two major migrations through the Delta. The first is an upstream spawning migration starting in mid-April before spring breakup and continuing on through most of May. The second migration is a downstream migration to Great

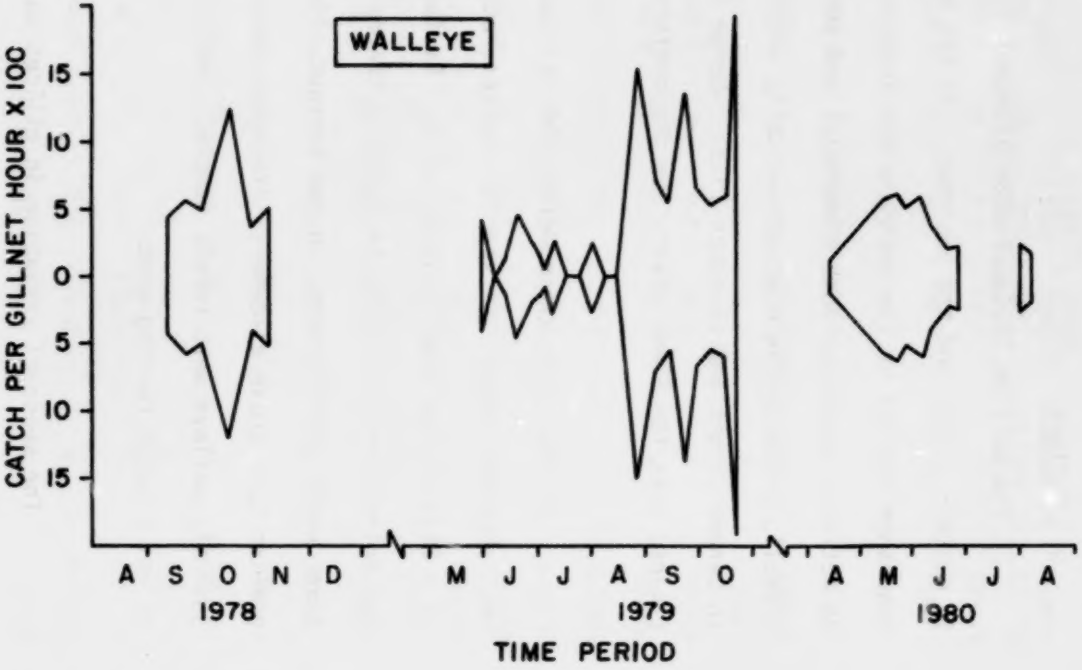

Figure 32. Seasonal pattern of catch per gillnet hour for walleye in the Slave River Delta, 1978 to 1980.

Table 54. Summary of walleye tag recaptures.

Date Tagged	Tagging Location	Date Recaptured	Recapture Location
Sept. 25, 1978	Slave River Delta	Aug. 7, 1980	Hay River, Great Slave Lake
June 5, 1979	Salt River	May, 1980	Slave River at Fort Smith
June 13, 1979	"	May 26, 1980	Slave River Delta
June 15, 1979	"	Sept. 25, 1979	Resolution Bay, Great Slave Lake
June 17, 1979	"	Oct. 21, 1979	Slave River Delta
Oct. 22, 1979	Slave River Delta	Jan., 1980	Simpson Islands, Great Slave Lake
Sept. 22, 1979	"	May 25, 1980	Slave River, Fort Smith
Sept. 24, 1979	"	May 10, 1980	"
Sept. 29, 1979	"	May, 1980	"
Oct. 21, 1979	"	May, 1980	"
Oct. 21, 1979	"	May, 1980	"
Oct. 21, 1979	"	June 14, 1980	Slave River, near Salt River
Oct. 7, 1979	"	May 20, 1980	Slave River Delta
Sept. 24, 1979	"	June 3, 1980	"
Oct. 10, 1979	"	Sept., 1980	Resolution Bay, Great Slave Lake

(continued)

Table 54 Concluded

Date Tagged	Tagging Location	Date Recaptured	Recapture Location
May 13, 1980	"	June 18, 1980	Slave River, near Salt R.
May 16, 1980	"	Sept., 1980	Resolution Bay, Great Slave Lake

Slave Lake that starts in late August and continues on until at least freezeup, and possibly later. The distribution of tag recaptures in Great Slave Lake also shows that walleye populations in the Slave River are members of a widely distributed population, extending from Hay River in the western end of Great Slave Lake to the Simpsons Islands in the east end. Upstream migrations in the Slave River go at least as far as Fort Smith (Table 54).

Normally, walleye spawn shortly after spring breakup at water temperatures ranging from 5.5 to 11.0°C (Scott and Crossman 1973). Preferred spawning areas are rocky areas in white water below falls or at the base of rapids, or boulder and coarse gravel shoals in lakes. The absence of preferred spawning habitat, ripe or recently spawned-out females, and young-of-the-year suggest that any walleye spawning in the Slave River Delta is highly unlikely. More likely spawning areas are located upstream at the rapids on the Slave River near Fort Smith. Tributary streams such as the Salt River downstream of Fort Smith may also be important.

Tables 55 and 56 summarize the spawning condition of walleye captured during the 1979 and 1980 spring spawning periods. In 1979, when spring breakup in the lower Slave River was

Table 55. The spawning condition of walleye taken in the Slave River Delta and the Salt River, May 30 to June 29, 1979. N=number of fish, G=green, R=ripe, SO=spawned out.

	MALES				FEMALES				Water Temp.
Date	N	%G	%R	%SO	N	%G	%R	%SO	(°C)
Slave Delta									
June 10	1	100							12.2
June 18	2		100						15.6
June 23	1			100					16.7
June 29	1			100	2	50		50	18.9
Salt River									
May 30	2		100						ND[a]
May 31	3		100		1	100			9.5
June 13	3	33.3	66.6		1			100	ND
June 14	1	100							17.0
June 16	3	33.3	33.3	33.3	2			100	17.0
June 17	3	33.3	33.3	33.3					18.5

[a] No Data

Table 56. Spawning condition of walleye taken in the Slave River Delta, April 16 to June 30, 1980. N = number of fish, G = green, R = ripe, SO = spawned out.

		Males				Females				Water Temp.
Date		N	%G	%R	%SO	N	%G	%R	%SO	(°C)
April	16	2		100						0
	18	3	33.3	66.7						0
May	10	3	33.3	66.7						5
	11	2		100						10
	12	1		100		1	100			8
	13	1		100		2	100			9
	14	4		100		1	100			9.5
	18	2	50	50						11
	20	4		100						11
	21	3		100		2	100			11.5
	22	4		100		2	100			13
	23	1		100						13
	24	1		100						13
	26	2		100		1		100		14
	29	2		100						12
	30	1		100						10
June	2					1	100			11
	4	2	100							12
	8	1	100							14
	12					2			100	16
	13	1			100					16
	14	2		50	50	2			100	15
	15	1			100					15
	19					1			100	17
	20					1			100	17.5
	21	1		100						17.5
	26					1			100	19
	27	1		100						19.5
	29	1		100		1			100	20
	30	1		100						ND

ND No Data

delayed until late May, few walleye were taken and only then in late June after water temperatures were fairly high. In 1980, 10 green females were taken from May 12 to June 2, at temperatures ranging from 5 to 14°C. Presumably, there were fish migrating upstream to spawn although, since water temperatures were close to optimum spawning temperatures, they may not have moved very far. The eight spent females taken from June 12 to June 29 were probably fish migrating back downstream to Great Slave Lake shortly after spawning.

Walleye in the Slave Delta ranged in fork length from 80 to 579 mm with most (80%) in the 280 to 479 mm fork length range (Figure 33). Three modal size classes were present: 300 to 319 mm, 380 to 399 mm, and 420 to 439 mm. There were no major differences in the length-frequency distribution of males and females, unlike those usually reported for more southerly populations where females typically predominate in the larger size classes (Scott and Crossman, 1973).

Age-length data for 240 walleye taken from the Slave Delta are summarized in Table 57. Significant differences between the age-length relationships of males and females could not be demonstrated and so the data were combined. Fish in the aged sample ranged from 0 to 18 years of age and 80 to 537 mm in fork length.

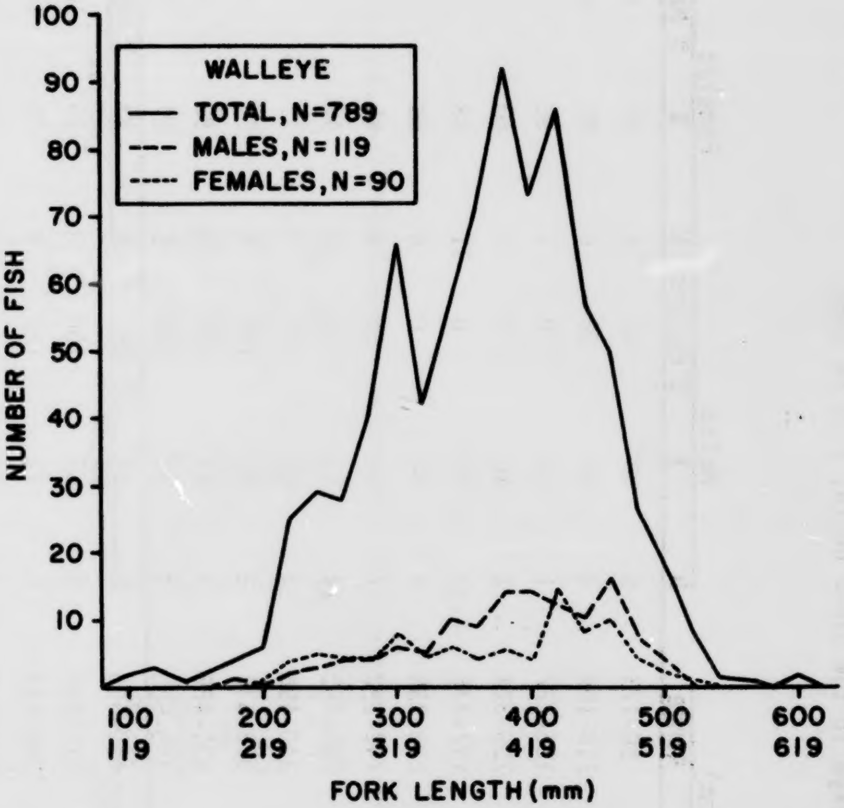

Figure 33. Length-frequency distribution of walleye taken in the Slave-River Delta, 1978 to 1980.

Table 57. Observed age-length relationship based on opercles, age at maturity, and age-specific sex ratios of walleye in the Slave Delta, 1978 to 1980.

Age	Fork Length (mm)			Males			Females			Unsexed	Total
	Mean	SD[a]	Range	N	%	% Mature	N	%	% Mature		
0	95.4	16.1	80-123	0	ND[b]	ND	0	ND	ND	7	7
1	145.5	32.1	118-189	0	ND	ND	0	ND	ND	4	4
2	201.2	53.5	126-277	1	50	0	1	50	0	4	6
3	260.6	36.6	209-324	2	40	0	3	60	0	10	15
4	263.9	38.3	197-376	12	52	0	11	48	0	14	37
5	279.1	34.8	218-336	4	40	0	6	60	0	11	21
6	339.7	44.0	242-393	7	54	56	6	46	0	1	14
7	358.7	34.7	280-463	14	58	43	10	42	0	6	30
8	385.4	37.5	340-496	12	63	75	7	37	0	4	23
9	413.1	47.6	326-537	6	46	100	7	54	14	0	13
10	436.1	27.2	401-486	7	47	100	8	53	50	0	15
11	445.3	31.0	405-500	3	33	100	6	67	50	0	9
12	450.9	23.4	412-495	6	43	100	8	57	87	0	14
13	446.7	23.8	416-486	6	67	100	3	33	100	0	9
14	463.1	49.9	390-512	5	71	100	2	29	100	0	7
15	467.0	31.1	410-497	4	67	100	2	33	100	0	6

Continued

Table 57. Concluded.

Age	Fork Length (mm)			Males			Females			Unsexed	Total
	Mean	SD	Range	N	%	% Mature	N	%	% Mature		
16	483.0	16.3	450-493	6	86	100	1	14	100	0	7
17	519.0	ND	ND	1	100	100	0	0	ND	0	1
18	454.5	34.7	430-479	2	100	100	0	0	ND	0	2
Total				98	55	65	81	45	28	61	240

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a Standard Deviation

b No Data

Walleye in the Slave Delta are slow to mature. A small percentage of females mature as early as age 9 but not all are mature until age 13. Males mature earlier, the youngest reaching maturity at age 6 and all reaching maturity by age 9. Once mature, walleye in the Slave Delta appear to spawn every year.

Walleye growth in the study area was similar to growth rates reported for walleye in Hay River, a tributary of Great Slave Lake, and the MacKay River, a tributary of the Athabasca River (Figure 34). The growth rate of the latter population was, however, based almost entirely on males. Walleye growth in the Athabasca River and Lake Athabasca was considerably faster than walleye growth in the Delta. Part of the observed differences may be due to different aging techniques: walleye ages in Lake Athabasca and the Athabasca River were based on scales while those in the Slave River Delta were based on operculum bones.

Length-weight relationships for walleye in the Slave River Delta were determined for a stratified sample consisting of three randomly selected fish of each sex in each 20 mm size. Analysis of covariance (ANCOVA) showed, however, that there were no significant differences in either the slopes (F = 0.021) or intercepts (F = 3.000) of the relationships for the two sexes.

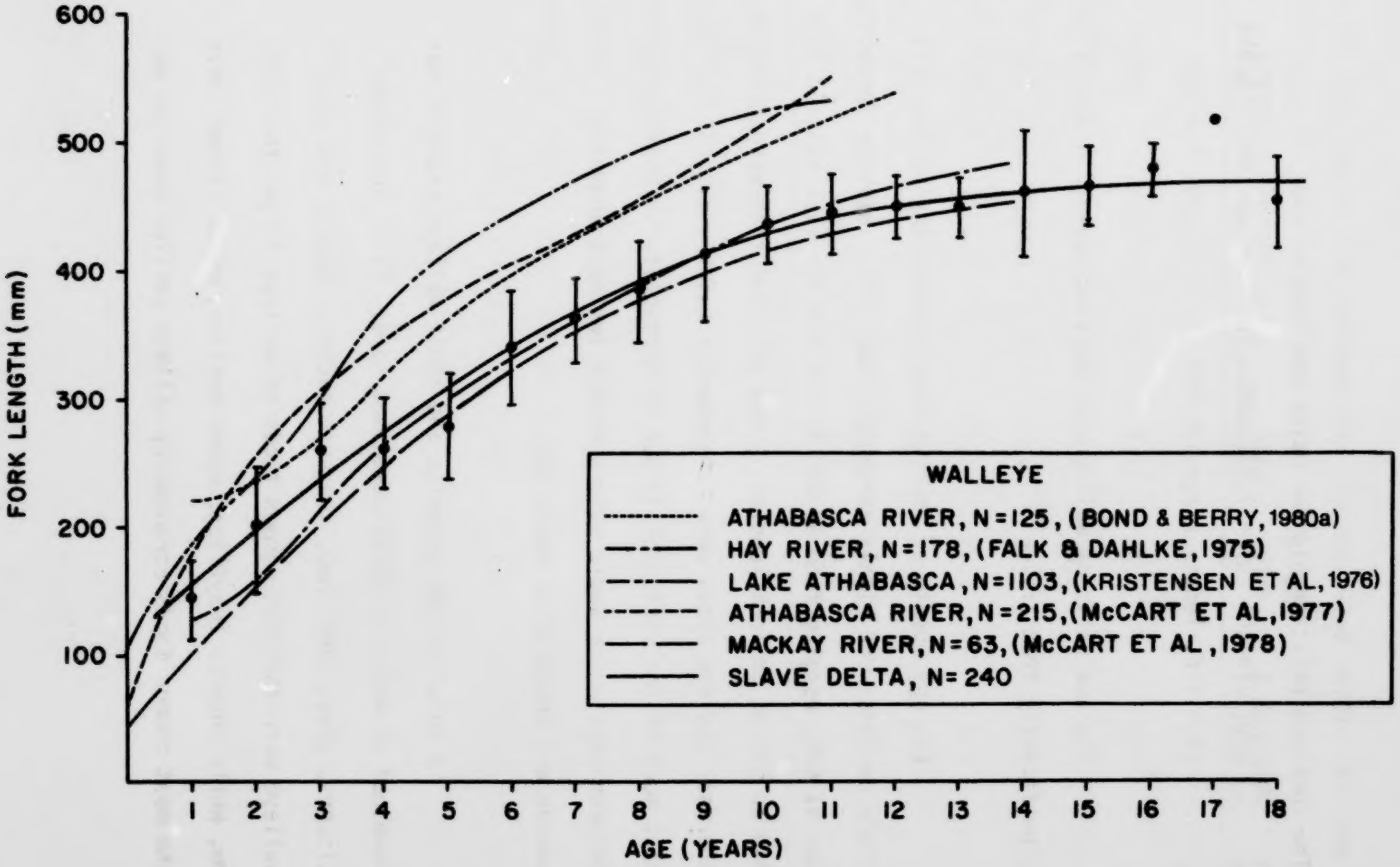

Figure 34. Comparison of the growth rate of walleye in the Slave Delta with five other populations in the Mackenzie Basin. Points with vertical lines are mean fork lengths ±1 standard deviation. Single points are individual fish.

The combined relationship for males and females was:

$$\text{Log}_{10} \text{ Weight (g)} = 3.272 \text{ Log}_{10} \text{ Fork Length (mm)} - 5.656$$

($N = 136$, length range 191-547 mm, $r = 0.99$, $P<0.05$).

The sex ratio of walleye in the study area did not differ significantly from 1:1.

The egg counts of four walleye sampled during the fall study periods were highly variable (Table 58). Average fecundity was 91 615, ranging from 69 228 to 113 414 for fish ranging from 449 to 537 mm in fork length. Since all four fish were taken in the fall and egg sizes were consequently quite small, it is likely that much of the variation is due to difficulty in distinguishing between eggs which would mature during the next spawning season and those which would not.

A total of 208 juvenile and adult walleye stomachs was examined of which 97 (47%) contained food. Fish, including ciscoes, pike, lake chub, longnose suckers, burbot and other walleye were the most common foods of walleye larger than 200 mm, while insects (mayflies, water beetles, midge larvae) were the most common foods consumed by walleye smaller than 200 mm.

Table 58. Egg counts from walleye taken in the Slave Delta, 1978 and 1979.

	Fork Length (mm)	Weight (gm)	Age	Egg Size (mm)	Gonad Weight (gm)	% Gonad Wt. of Body Wt.	Number of Eggs
	449	1300.0	12	1.0	60.6	5	106314
	459	1234.5	12	1.1	66.0	5	69228
	473	1718.0	10	1.2	78.8	5	77506
	537	1839.0	9	0.9	87.3	5	113414
Mean	479.5	1522.9	10.7	1.1	73.2	5.0	91615
SD[a]	39.6	300.5	1.5	0.1	12.1	0.0	21536
Range	449- 537	1234.5- 1839.0	9- 12	0.9- 1.1	60.6- 87.3	-	69228- 113414

[a] Standard Deviation

H. Minor Species

For the purposes of this report, minor species in the Slave River Delta are considered to be all of the smaller species present and those which, while large, are relatively rare. In what follows, various aspects of their distribution, abundance, and life history are briefly discussed.

1. Arctic Lamprey:

The Arctic lamprey (*Lampetra japonica*) occurs in the Slave River as far upstream as the rapids at Fort Smith (Scott and Crossman 1973). Normally parasitic on lake trout, lake whitefish, and inconnu, there was no evidence during this study to indicate that any of the fish captured had been parasitized by lampreys. Twenty-one Arctic lamprey ammocoetes, ranging from 15 to 88 mm in total length, were captured, most of them in drift nets in May, June, and July. One adult lamprey was found in a burbot stomach.

2. Chum Salmon:

The chum salmon (*Oncorhynchus keta*) ascends the Mackenzie River as far as the rapids at Fort Smith on Slave River. Keleher (1972) suggests that the migration of this species up the Slave River is not an annual occurrence, and most local fishermen agree.

One chum salmon was gillnetted by a local fisherman on October 12, 1979, above Site 14 on the Slave River (Figure 2). This fish was an age 4 ripe male, 753 mm in fork length, and approximately 5900 g in weight. Additional captures in 1979 were reported during October and November further up the Slave River in the vicinity of Hook Lake and Fort Smith.

3. Round Whitefish:

One round whitefish (*Prosopium cylindraceum*) was captured and tagged in a beach seine in the Salt River on May 30, 1979.

4. Arctic Grayling:

The Arctic grayling (*Thymallus arcticus*) is an important sport fish in both the outlet and most tributaries of Great Slave Lake. It is, however, very rare in the Slave River. One was captured by a local fisherman at Site 24 on the Slave River, October 7, 1978. A second 364 mm fork length green female, age 7, was captured at the same location on May 21, 1980.

5. Lake Chub:

Lake chub (*Couesius plumbeus*) have the most widespread northern distribution of any North American cyprinid (McPhail and Lindsey 1970). In the Mackenzie drainage, they occur as far north as the Mackenzie River Delta. This important forage species, along with the emerald shiner and trout-perch, accounted for 75% of the total catch of small fish within the study area. The average catch per 100 m of shoreline seined was 7.5 in 1979 and 4.6 in 1980.

Lake chub reached their greatest abundance in the minor channels and central portion of the Slave River Delta. They were, however, commonly taken elsewhere in the Delta and appear to be highly adaptable to a wide range of habitats. In 1979, there were peak catches in each major sampling period (Figure 35). In 1980, they were abundant in early May and late June but relatively rare at other times. Lake chub sampled in the study area ranged in fork length from 19 to 127 mm, with a modal peak at 30 to 39 mm (Figure 36).

The lake chub appears to be a very opportunistic feeder. Of 63 stomachs found to contain food, corixids and chironomids predominated (Table 20) although oligochaetes, clams, snails, cladocerans, water beetles, caddisfly, mayflies, stoneflies, and small fish were also found.

6. Spottail Shiner:

The spottail shiner (*Notropis hudsonius*) is the most northerly distributed species of genus *Notropis*. It is often the

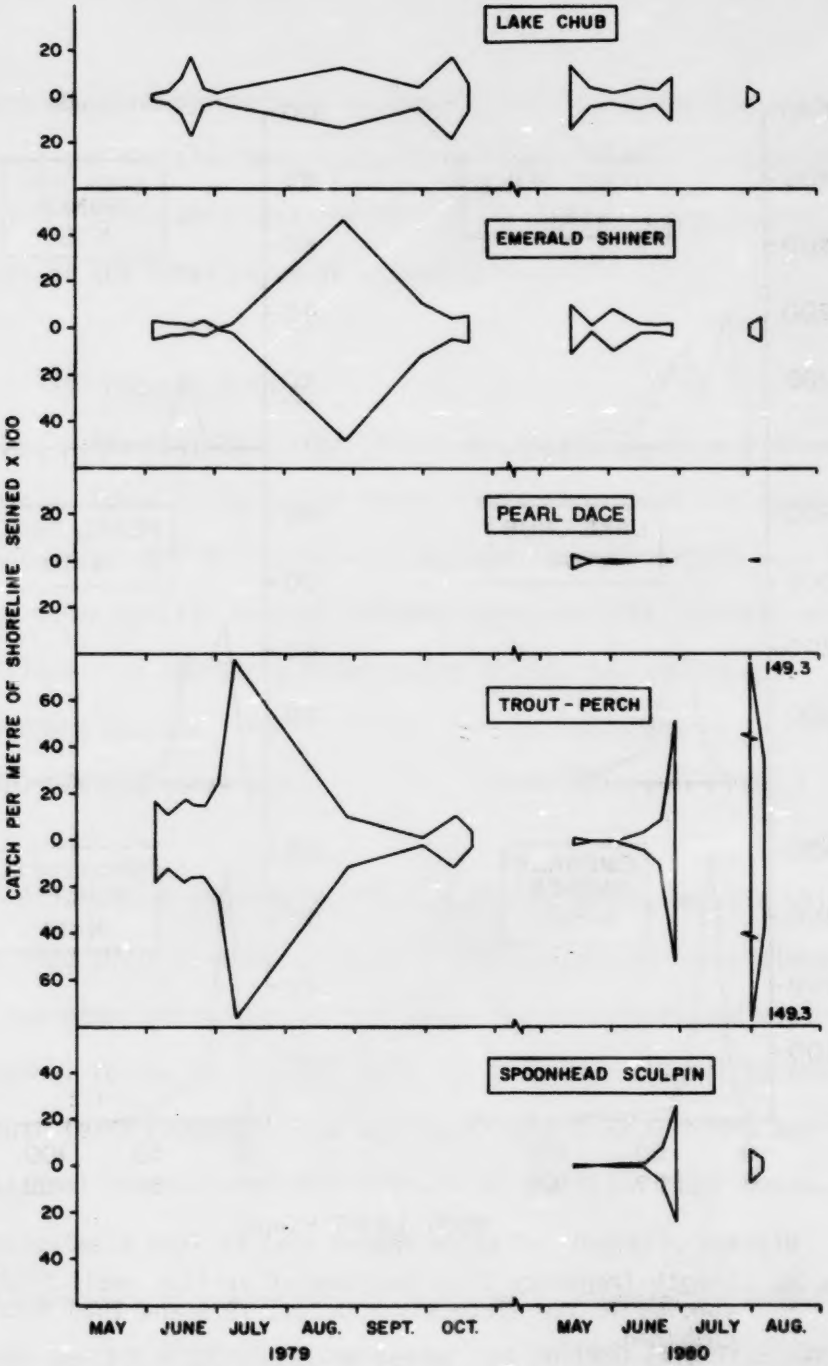

Figure 35. Seasonal patterns of abundance in minnow seine catches for various small fish species in the Slave River Delta 1979 and 1980.

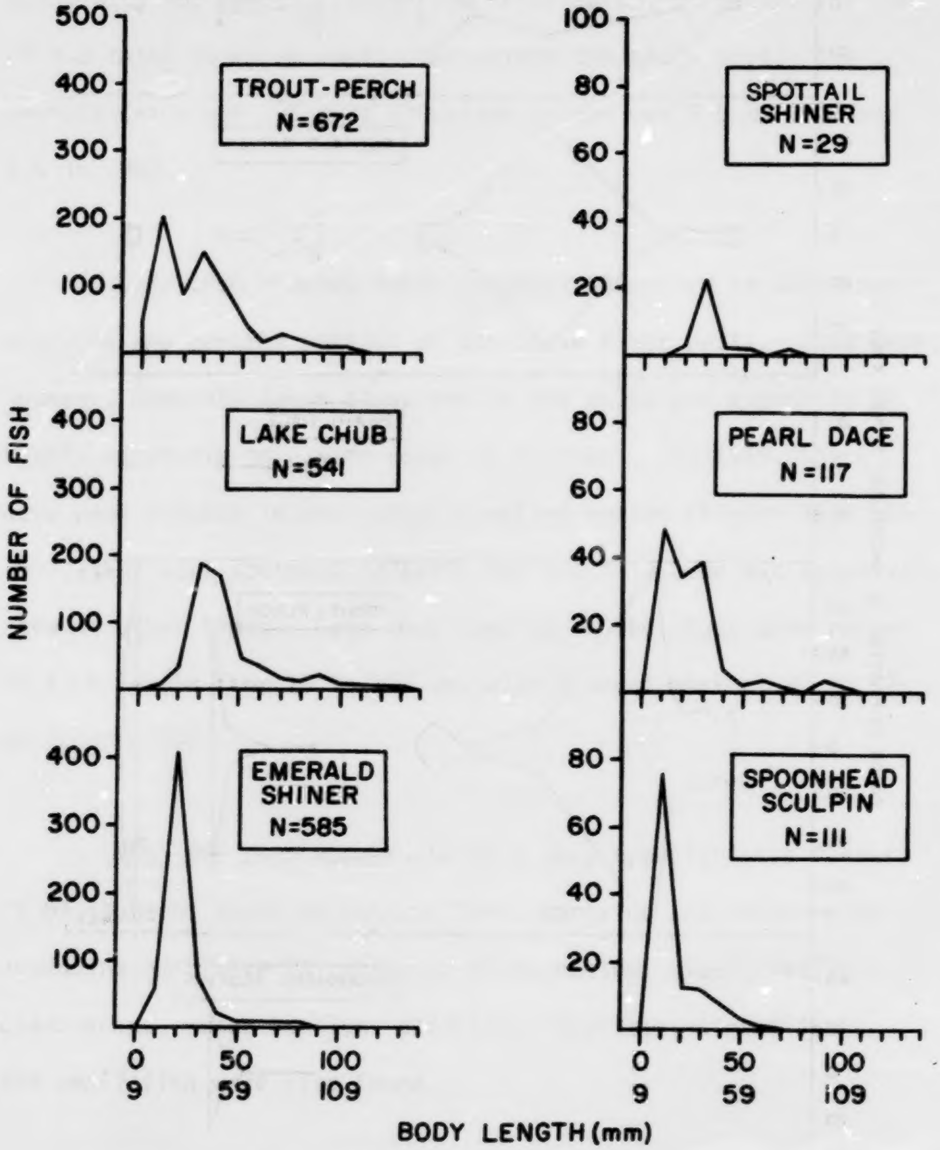

Figure 36. Length-frequency distributions of various small fish species in the Slave River Delta, 1979 and 1980 data combined.

most abundant cyprinid in northern lakes (Scott and Crossman, 1973) and has also been captured in large, turbid northern rivers. A total of 87 were captured during the present study, representing 0.8% of the total catch in minnow seines.

7. Emerald Shiner:

The emerald shiner (*Notropis atherinoides*) is a pelagic species found in lakes and large rivers throughout its extensive range. It is a schooling species, and is an important food fish for other species such as inconnu, northern pike, burbot, and walleye. In the Slave River Delta, it was the second most abundant species taken in minnow seines, representing 13.8% (N = 1591) of the total catch.

Widely distributed throughout the Delta, emerald shiners reached their greatest numbers in well vegetated areas along the outer edges of the Delta including the Slave River and Resdelta Channel to the north, and Nagle and Steamboat Channel to the south (data from Tables 16 and 19). Figure 35, showing the seasonal abundance of this species in the Slave River Delta, indicates a peak in late August of 1979. Overall, emerald shiners were approximately three times as abundant in 1979 (12.2 fish per 100 m of shoreline seined) as in 1980 (4.2 fish per 100 m of shoreline seined). Ranging from 11 mm to 89 mm in length, most were young-of-the-year in the 20 to 29 mm fork length range (Figure 36).

Most (67%) of the 75 emerald shiner stomachs examined were empty. Corixids dominated in the 25 stomachs containing food, followed in order by midge and ceratopogonid larvae, hymenopterans, (wasps, ants), water beetles, adult midges, stoneflies, copepods, and cladacerans.

8. Pearl Dace

Pearl dace (*Semotilus margarita)* favour cool, clear streams in the south and bog drainages in the north (Scott and Crossman 1973). In the Slave River Delta, they reached their highest concentrations in Middle Channel, East Channel, and most of the minor side channels. Present throughout the open water period, they reached their greatest concentrations in spring and early summer. A total of 200 pearl dace were captured during the study (1.7% of the total seine catch), most of them in 1979 (N=128). They ranged from 12 mm to 105 mm in fork length with two modal peaks at 10 to 19 mm and 30 to 39 mm.

Of 31 pearl dace stomachs examined, 21 contained food. Chironomid larvae (11 stomachs) and corixids (8 stomachs) were the most common foods. Snails were the only other item recorded (2 stomachs).

9. White Sucker

The white sucker (*Catostomus commersoni*) usually inhabits warm, shallow lakes and bays, and tributary rivers of larger lakes. In Great Slave Lake, it appears to be limited to Yellowknife Bay and the northern arm near Fort Rae (McPhail and Lindsey 1970). It is uncommon in the Slave River.

Only four white suckers were caught in minnow seine hauls, totaling less than 0.1% of the catch and ranging in size from 63 mm to 127 mm fork length. An additional eight white suckers ranging from 155 mm to 470 mm fork length were also caught in the Slave River, Resdelta Channel, and side channels using gillnets, traps, and beach seines.

Four white suckers (425 to 452 mm fork length) were captured with a beach seine in the Salt River during early June. One of these fish was a ripe female.

10. Ninespine Stickleback

The ninespine stickleback (*Pungitius pungitius*) occurs widely throughout North America, and is occasionally an important food fish for larger species such as pike, inconnu, and walleye. Only 17 specimens were ever captured in the Slave River Delta. These were not subjected to detailed life history analysis.

11. Trout-Perch

The trout-perch (*Percopsis omiscomaycus*) has a wide distribution throughout central and northern North America. Although typically a lake species in the east, it is also found in large turbid rivers throughout most of the Mackenzie River drainage. Trout-perch were captured in all the main channels of the Slave Delta, as well as many side channels and quiet back waters. No distinct habitat preferences were noted.

The trout-perch was, overall, the most abundant small fish taken in minnow seines, accounting for 50% (N=5774) of the total minnow seine catch. Seasonally, they were most abundant in the summer and least abundant in early spring and late fall (Figure 35). In the study area, trout-perch ranged from 6 to 104 mm in fork length with two modal peaks at 10 to 19 mm and 30 to 39 mm (Figure 36).

Of 133 trout-perch stomachs examined, 40 (30%) were found to contain food. Chironomids (28 stomachs) were the most frequently eaten item followed in order by mayflies (4 stomachs), clams, amphipods, fish (2 stomachs), snails, caddisflies, and corixids (1 stomach).

12. Yellow Perch

The yellow perch (*Perca flavescens*), a shallow water species near the northern limit of its range in the Slave River, occurs there rarely when compared with walleye, the only other percid species common to the Mackenzie drainage.

Minnow seining in the study area yielded 86 yellow perch, 65 of which were taken in 1979. Most were taken in Middle Channel, but were also present in East Channel and Old Steamboat Channel. Yellow perch sampled during the study ranged from 10 mm to 53 mm in fork length with most in the 10 to 19 mm range. One mature female, 212 mm fork length, was gillnetted in September in the lower Slave River.

13. Slimy Sculpin

The slimy sculpin (*Cottus cognatus*) has the most extensive range of any *Cottus* species in Canada. Widespread throughout the Mackenzie River drainage, it prefers clear, gravelly streams where it is often codominant with Arctic grayling. During the present study, only eight slimy sculpins were captured, all of them immature and ranging from 15 to 45 mm in total length.

14. Spoonhead Sculpin

The spoonhead sculpin (*Cottus ricei*) is the most easily identified member of the genus *Cottus* in North America, and, unlike the slimy sculpin, is widespread in large, turbid rivers of the north. A total of 569 specimens were taken in the Slave River Delta, representing 4.9% of the total minnow seine catch. In some years, it is one of the most common small fish species present.

Most (94%, N=535) of the spoonhead sculpins sampled during the study were sampled in 1980. Most of these in turn were young-of-the-year (Figure 36) that quickly peaked in abundance in late June and then declined by early August (Figure 35).

Of 33 spoonhead sculpin stomachs examined, 24 were found to contain food. Chironomids (23 stomachs) were the most common items recorded, followed by clams (5 stomachs), fish eggs (4 stomachs), corixids, mayflies (2 stomachs), and snails (1 stomach).

Chapter VII

COMMERCIAL, DOMESTIC, AND SPORT FISHERIES IN THE SLAVE RIVER DELTA

Descriptions of the commercial, domestic, and sport fisheries of the Slave River Delta are, in what follows, largely based on Bodden's (1980) studies, supplemented with some of our own observations and the comments of Mr. Ernest Beaulieu which were included in an earlier version of this section of the report (Tripp et al. 1980). Mr. Beaulieu, a longtime resident of Fort Resolution and one of our field assistants for most of the study, has hunted, trapped, and fished in the Delta for many years, and is therefore well acquainted with most of the local fisheries.

In addition to the foregoing sources of information, detailed records of domestic fishing in the Slave River Delta were kept during the early stages of this study in the fall of 1978.

According to Bodden (1980), fish have traditionally been an important source of food for the people of Fort Resolution, providing up to 40% of their own and 100% of their dogs' food supply. More recently, however, with the increased use of snowmobiles and imported foodstuffs, the amount of fish harvested has declined.

Lake whitefish and inconnu are the most highly prized fish for both man and dogs, followed by burbot, walleye and, to a lesser extent, northern pike and longnose suckers. Ciscoes and goldeye are used primarily as dog food.

Fish destined for human consumption are either boiled or fried immediately, or smoked and hanged to dry for later consumption. Fish taken during the summer for dog food are hanged or stored in pits to dry or semi-rot in the air. The incidence of putrification is not regarded as serious since it is believed that fish in the early stages of decomposition are more nutritious for dogs than those in the fresh form (Sinclair et al., 1967). Fish taken in autumn for dog food or trapping bait are frozen for use throughout the winter.

There is no commercial fishing in the Slave River Delta, most of which lies within a 10 mile fishing zone set up to protect the fish resources for residents along the south shore of Great Slave Lake. Residents of Fort Resolution who do have commercial fishing licenses operate mainly in the vicinity of the Simpson Islands (Administrative Area V), a summer fishery which, in 1978, extended from August to October (Moshenko and Low, 1979). It is basically an inshore fishery with quotas on lake whitefish and lake trout and restrictions on mesh size, but no restrictions on the length or number of nets used. The fishery is mainly for lake whitefish although lake trout, pike, inconnu, and walleye are also important. Significant numbers of burbot, ciscoes, and longnose suckers are also taken.

Residents of Fort Resolution who fish domestically do so in three main areas: Resolution Bay, the Little Buffalo River, and the Slave River Delta. Fishing in Resolution Bay occurs year round while fishing in the Little Buffalo River is concentrated during the spring for longnose suckers, during the summer for walleye, and in the fall during the upstream spawning runs of lake whitefish and inconnu. Burbot are heavily fished just before freeze-up.

In the Slave River Delta, the seasonality, intensity, and duration of domestic fishing appear to be determined by several factors which may vary from year to year. These include the number of dogs owned by the fishermen, as well as hunting or trapping success. While there are a few people who fish throughout the year, fishing intensity is generally greatest during the fall spawning migrations of the major species in the Slave Delta, especially lake whitefish, inconnu, and burbot.

A total of 13 traditional domestic fishing sites in the Slave Delta are described by Bodden (1980). Of these, five are located along Resdelta Channel, and eight are located along Middle Channel, Old Steamboat Channel, Nagle Channel, and several other minor channels. These sites have a history of past use, and the rights to their fish resources are usually assigned to the family camps located nearby. Generally, camps located outside Resdelta Channel are used primarily as bases for muskrat trapping with fishing a secondary activity. This is not surprising in view of the low fish catches in these areas. As shown earlier, gillnet catches in Resdelta Channel and the lower Slave River are, on the average, five times higher than those elsewhere in the Slave Delta.

Domestic fishing also occurs in the lower Slave River (sites 8, 11, 14, 19, 21, and 23; Figure 2). Fishing at these sites was generally more intensive and extended over a greater length of time than fishing in the main portion of the Slave Delta. This was particularly true during the open water period because muskrat camps in the Delta were rarely used before mid-October and much of the fishing in this area is associated with muskrat trapping.

Domestic fishing methods in the Slave River Delta vary with the season. Gillnets are used during the open water period, although rarely more than two at a time. The most common mesh size is 11.4 cm stretched mesh, although 12.7 cm and 14.0 cm are also used. The length and depth of the nets vary as well, depending on how often the net has been repaired and where it is being used. Nets seldom exceed 45.7 m in length (most are 18.3 m long) and 3.7 m in depth.

Shorter gillnets are occasionally used during winter. Baited set lines are, however, the preferred method of fishing under the ice, particularly for burbot. Generally, five lines, each bearing about five hooks, are fished at one time, allowing fishermen to quickly retrieve and reset each line and still keep a large number of freshly baited hooks in the water.

Domestic fishing in the Slave River Delta is, for the most part, "unorganized" -- i.e. fishing is conducted by people not sponsored or assisted in their operations by the Department of Indian Affairs and Northern Development or Canada Health and Welfare. This type of fishing is carried out to provide food for individuals, their families, and their dogs. Fish as a source of dog food is particularly important, since the intensity of unorganized fishing by the people of Fort Resolution is largely determined by the number of dogs they own. Bodden (1980) estimates that during the winter months, each dog consumes one to two kilograms (2-4 pounds) of fish per day.

Exploitation levels of the domestic fishery in the Slave River Delta were estimated by Bodden (1980). His values were obtained by interviewing 168 males who were potentially active in fishing during the 1976-1977 season. He states that the estimates are likely higher than normal because of unusually good hunting and trapping conditions during his study period. During the open water period in 1979, we observed only four people fishing with any regularity and, in 1980, only two people.

An estimated total of 9715 fish was taken by domestic fisheries in the Slave River Delta during the 1976-1977 season. Burbot were estimated to account for 45.3% of the total catch, followed in order by lake whitefish (25.7%), longnose sucker (10.8%), inconnu (9.4%), pike (7.9%), and walleye (0.9%).

Lake trout used to represent a significant portion of the total catch when set lines were used under the ice at the mouth of the Delta channels. However, because of the decline in catches, as a result of overexploitation elsewhere in Great Slave Lake (Keleher 1972), this fishing method is no longer practised.

The relative abundance of the various fish species taken in domestic fisheries was very different from our own catches. Lake whitefish and inconnu, for example, represented about 35% of the total domestic catch, but only 4.5% of the fish taken in our nets. Most of the difference is thought to be due to, first, the larger mesh sizes used in domestic fishery and, second, the greater effort expended by domestic fisheries during late fall and early winter when these species are abundant compared to spring and early summer.

There was no evidence of any sport fishing in the Slave River Delta during the course of this study, undoubtedly because of the remoteness and relative inaccessibility of the area. No fishing lodges lie within the Delta, and only one seasonal access road (to Nagle Channel) is available. Pike and walleye were, however, among the most abundant fish species taken, and could, potentially, make an important contribution to sport fishing in the region.

Chapter VIII

SYNTHESIS

The Slave River Delta fisheries study was designed to provide information concerning fish populations and their habitats useful in assessing the potential effects of developments elsewhere in the drainage. The report includes descriptions of:

a) The life histories, seasonal movements, distribution, and relative abundance of each major fish species present in the Delta;

b) The species composition, distribution, and relative abundance of benthic macroinvertebrates in the Delta; and

c) Seasonal variations in water temperature, dissolved oxygen, pH, conductivity, turbidity, and suspended sediments.

Additional surveys of the upper Slave River region near Fort Smith were undertaken to provide first, more information on fish movements in the drainage, and second, some idea of the importance of the upper Slave River as a spawning area. Following our own recommendations in the second interim report (Tripp et al. 1980), the invertebrate sampling program in the Delta was also expanded to include spring and summer samples. The former were benthic samples taken throughout the Delta in order to describe fall to spring variations in benthic species composition, distribution, and standing crop. The latter were sweep net samples taken nearshore in an attempt to relate the food habits and relative abundance of small fish to nearshore habitat types. Major ion and macronutrient concentrations were determined on a regular basis to complement Water Survey of Canada's sampling program.

What follows includes:

1. A brief description of the present fishery resources of the Slave River Delta;

2. A brief assessment of the effects that developments upstream might have on the fishery resources of the Delta; and

3. Recommendations for further studies.

A. Description of Fish Resources

The Slave River Delta is used by at least 23 species of fish. Of these, eight are relatively rare and should probably be considered as incidental species more closely associated with other parts of the Slave River-Great Slave Lake drainage. They include Arctic grayling and slimy sculpins, both of which are more properly identified with clear, rubble-bottomed streams, and the large bodied lake ciscos which are more closely associated with Great Slave Lake. Others like pearl dace, ninespine sticklebacks, and yellow perch are probably fish which have wandered downstream out of small streams and lakes draining into the Slave River, while spottail shiners and white suckers could be related to larger populations in both Great Slave Lake and the upper mainstem Slave River.

In contrast to the relatively uncommon species listed above, northern pike, lake chub, emerald shiners, flathead chub, and trout-perch are abundant in the Delta for most of the open water period. Although data are scarce, these species do not appear to undertake extensive migrations and probably represent fish which remain in the vicinity of the Delta and lower Slave River year-round.

Between fish which rarely use the Delta and those which use the Delta year-round, there are eight important species which can be separated into one of three categories:

1. Fish that migrate through the Delta,
2. Fish which feed in the Delta during the summer, and
3. Fish that spawn in the Delta.

The first category includes inconnu, lake whitefish, and probably spoonhead sculpins. As adults, these fish do not feed or spawn in the Delta but, instead, migrate through the Delta to spawning and feeding areas located elsewhere.

Spoonhead sculpins probably migrate upstream through the Delta in early spring, in some years probably before breakup. Their spawning areas are unknown. Although gradual and not readily apparent, inconnu and lake whitefish appear to migrate upstream through the Delta in late summer and early fall. Their major spawning areas are believed to be upstream in the vicinity of the rapids at Fort Smith where large concentrations of both species occur during late fall.

Some lake whitefish apparently return to Great Slave Lake shortly after spawning while others remain to overwinter in the Slave River, returning to the lake the following spring. Inconnu, on the other hand, apparently move back to Great Slave Lake shortly after spawning since very few are captured in the river in the spring and summer. The movements of young-of-the-year inconnu are unknown but young-of-the-year lake whitefish drift downstream to Great Slave Lake shortly after emergence. Depending on how fast the Delta clears itself of ice, they may also feed for a short period in the Delta.

Goldeye, longnose suckers, and walleye fall into the second category which includes fish that spawn elsewhere but return to feed in the Delta for most of the open water period. The results of tag recoveries, late winter netting under the ice, and seasonal variations in spawning condition indicate that both longnose suckers and walleye migrate upstream from Great Slave Lake to spawning areas in the Slave River before breakup occurs in the Slave River Delta. Some return to feed in the Delta shortly after spawning while others return in early fall to feed before continuing on to overwintering areas in Great Slave Lake. Goldeye in the Delta are believed to be closely related to goldeye populations in the upper Slave River region. Instead of moving upstream out of Great Slave Lake like walleye or longnose suckers, they are thought to move downstream into the Delta after spawning, returning upstream in the fall.

The burbot and small bodied ciscos fall into the third category which includes major fish species that spawn extensively in the Slave River Delta. Their principal spawning areas appear to be Resdelta Channel and the lower reaches of the Slave River. Ciscos move into the Delta in late fall, spawn in late October, and presumably return to the lake after freeze-up. Burbot accompany the ciscos and spawn from freeze-up to late December. Although it is likely that most return to Great Slave Lake, it appears that some burbot also move upstream as far as Fort Smith after spawning. Young-of-the-year burbot normally rear in the Delta after emerging while young-of-the-year ciscos probably rear in Great Slave Lake.

Goldeye, pike, longnose suckers, burbot, and walleye together dominate the catch in variable mesh gillnet gangs and thus best typify the large fish fauna of the Slave River Delta. Interestingly, three of these species (pike, burbot, and walleye) are piscivorous predators while another (goldeye) is an opportunistic feeder well adapted to feeding in the turbid waters of the Slave River. Since the longnose sucker appears to be the only large fish species present that is adapted to feeding on the benthic invertebrate fauna, small fish species largely represented by emerald shiners, lake chubs, and trout-perch are probably a more important link in the transfer of energy from the Delta's invertebrate community to larger fish.

With the exception of goldeye, large fish tend to be three or four times more abundant in the lower Slave River and Resdelta Channel than anywhere else in the Delta. Goldeye are more evenly distributed as are most of the small fish species, including young-of-the-year of larger species like pike and burbot. Overall, the highest densities of small fish are found in shallow, well vegetated habitats where a suitable combination of protective cover and food is provided. Shallow, barren habitats have enough food but no cover, while deep, vegetated areas have sufficient cover but less food.

Seasonally, the highest concentrations of small fish, including young-of-the-year, occur in late spring and summer. Large fish, on the other hand, are most abundant in early spring and late fall when the majority of all spawning, post-spawning, feeding, and overwintering migrations occur. Movements during early spring may pass undetected, however, when breakup in the Delta is delayed as it was for example in 1979. The results of late winter surveys indicate that there is little activity in March but, by April, spring spawning fish are beginning to move upstream.

Annual variations in gillnet catches likely reflect changes in sampling efficiency more than real changes in fish abundance. In 1980, for example, breakup was almost a month earlier than in 1979, thus allowing the field crew to more efficiently sample fish during their spring spawning and post-spawning migrations. As another example, the larger gillnet catches of small-bodied ciscos in 1979 compared to 1978 are thought to be the result of an overall increase in their average fork length and thus their susceptibility to capture.

Annual variations in the abundance of small fish appeared to be more significant. Young-of-the-year pike and burbot were relatively more abundant in 1979 than in 1980, while lake whitefish and spoonhead sculpin young-of-the-year were common in 1980 but not in 1979. Others, like trout-perch, were considerably more abundant in 1980 than in 1979 while lake chub, flathead chub, and emerald shiners all showed a decline.

Table 59 compares the average catch for 24 h standard gillnet gang sets in the Slave River Delta with those in the Athabasca River Delta and the Athabasca River. In each case, the comparisons are based on fish collections taken at similar times during the open water period and in similar gear. Data for the Athabasca River Delta are from Bond and Berry (1980b), while those for the Athabasca River are from Bond and Berry (1980b), Jones et al. (1978), and Tripp and McCart (1979).

Catches in the Slave River Delta, approximately six fish in a 24 h set, were less than half of those in the Athabasca River Delta, and half-again less than those on the Athabasca River. Most of the differences between the two deltas are due to larger populations of lake whitefish, goldeye, and walleye in the Athabasca Delta. In the Athabasca River, higher numbers of flathead chub and longnose sucker are also present. Ciscos which spawn in the Slave River Delta in extremely large numbers are poorly represented in gillnet catches because of their small size while burbot, which also spawn in the Delta in considerable numbers, are taken primarily on set lines after freeze-up.

Table 59. Comparison of standard gillnet gang catches in the Slave River Delta (1978 to 1980), Athabasca River (1977), and upper Athabasca River (1977 to 1978).

Species	CATCH PER 24 HOUR GILLNET GANG SET Slave River Delta (783 sets)	Athabasca River (33 sets)	Upper Athabasca River (63 sets)
Ciscos	0.27	0.00	0.00
Lake whitefish	0.25	2.24	3.21
Inconnu	0.06	0.00	0.00
Goldeye	1.13	5.55	10.68
Northern pike	1.23	2.03	1.73
Flathead chub	0.27	0.39	2.54
Longnose sucker	0.72	0.82	1.79
White sucker	0.01	0.00	0.22
Burbot	0.93	0.00	0.19
Walleye	1.13	3.45	3.38
Total	6.17	14.48	23.75

The data suggest that, with the exception of ciscos and burbot, populations of large fish are comparatively small in the Slave River Delta and that it is probably more important as a migratory pathway rather than as a feeding area.

B. Sensitivity to Environmental Change

Hydroelectric dams on the mainstem upper Slave River drainage are likely to have the greatest impacts on the ecology of the Slave River Delta in the near future. In our view, most of the effects of such developments are likely to be the results of changes in suspended sediment loads, nutrient loads, and seasonal flow rates. Because of the distances involved between the Delta and the sites most likely to be developed, other changes related to factors like water temperature and dissolved oxygen concentrations would probably not be as great.

As described earlier, the Slave River Delta exists as a result of sediment deposition caused by a reduction in current speeds when the Slave River enters Great Slave Lake. Its continued existence is dependent on the River contributing sediments in quantities greater than those which currents and waves can distribute. A large reservoir upstream of a dam on the Slave River would trap sediments which now enter the Delta and Great Slave Lake. If the reduction in suspended sediment loads entering these areas is such that the quantity of sediments lost through currents and wave action exceeds that contributed from upstream, there may be an overall decrease in the size of the Delta together with a simplification of its morphology.

Because of their high silt loads, spring floods in the Slave River Delta probably account for most of the sediments deposited in a year. Most are deposited in two locations, along the sides of channels (which results in the formation of levees) and on the broad, low-lying flood terraces near the lake (which results in further advances by the Delta into Great Slave Lake). Other new habitats are created when new channels are formed or when silt deposits which have accumulated in other channels during periods of low summer or winter flows are flushed out and deposited elsewhere. By recharging the Delta with water, spring floods also keep the vegetation in low-lying areas at an early successional stage largely characterized by horsetails and sedges.

If both the reduction in suspended sediment loads and spring flood levels is severe enough, low-lying flood terraces at the edge of the Delta might eventually be carried away, causing part or all of the Delta to retreat to the higher, less active portions. Willows and alders, followed later by poplars and spruce, would begin colonizing areas which are normally maintained at early successional stages by periodic flooding. In time, minor and finally major channels would shrink and disappear until a new equilibrium was reached. The end result would be a smaller, simpler kind of delta. Until then, it is possible that the creation of new lakes, ponds, and marshes as channels change during the transition period may actually increase habitat diversity and production for a short period.

A smaller and simpler kind of Delta would mean a significant loss of shoreline habitats and therefore major rearing and feeding areas for small fish species like lake chub, emerald shiners, and trout-perch, and young-of-the-year of large species like pike and burbot. Further reductions in small fish numbers may also occur along the remaining shoreline if the protective cover and food provided by early successional stage aquatic macrophytes are reduced by later successional stages.

If the present rearing areas of young-of-the-year pike and burbot and other, small fish species represent a significant portion of the total rearing area used by these species, then a reduction in the overall size of the Delta may result in lower young-of-the-year survival rates. In time, adult population levels would be expected to decline to a level which can be supported by the available rearing area.

Other large species would be relatively unaffected by the formation of a smaller Delta. Ciscos which now spawn in Resdelta

Channel and the lower Slave River, for example, would probably still spawn in the main channel, while inconnu and lake whitefish, the two most important domestic and commercial fish species present, would undoubtedly continue to migrate through the Delta to spawning areas located upstream. Other species like goldeye, longnose suckers, and walleye, would also be relatively unaffected.

One other factor associated with reservoir development which might affect fish populations in the Delta is related to reductions in nutrient loading. Following a brief period of enhanced nutrient concentrations immediately after closure as nutrients are leached from newly inundated soils, reservoirs commonly act as nutrient sinks so that concentrations and loadings downstream are reduced (Ryder 1978). This can affect production at both the primary and higher trophic levels, the latter including fish. The relationships between nutrient loadings and primary and higher level production in river deltas are little understood and probably very complex and we have no basis for estimating the potential impact of reduced nutrient loadings on aquatic communities of the Slave River Delta. Ryder (1978) does, however, summarize information which suggests that, since the construction of the Aswan High Dam on the Nile River, there has been a significant decline in fish yields in the Nile Delta Lakes, 900 km downstream. Ryder suggests that this may be the result of reduced nutrient supply. Aside from possible effects in the Delta, the most serious consequences of reductions in nutrient loadings will probably be in Great Slave Lake, which might lose a significant proportion of its total nutrient loading. This might ultimately affect fish production in the same way that reductions in nutrient loadings from the Nile River have apparently led to a decline in the Egyption fishery in the eastern Mediterranean (Ryder 1978).

C. Recommendations for Further Study

Further studies on some of the physical characteristics of the Slave River Delta would provide a better understanding on how fish populations in the Delta might change under different hydrological conditions. It would be useful, for example, to know what the lakeward growth rate of the Delta is, what portion of this growth is attributable to sediments deposited at peak, intermediate, and base flow rates, and what portion of the sediment load is derived from sediments originating downstream of potential damsites. It would also be useful to know what the substrate characteristics are in the middle of Resdelta Channel and the lower Slave River where ciscos and burbot apparently spawn, and in the Slave River downstream of Rapids of the Drowned where lake whitefish, inconnu, longnose suckers, and walleye may be spawning.

Future studies directly concerned with the impact of hydroelectric developments on fish populations will undoubtedly have to address the potential problems associated with fish passage, gas supersaturation, abnormal temperature regimes, abnormal hydrological regimes, increased sedimentation in reservoirs upstream of damsites, and reduced sediment and nutrient loads downstream. For this reason, our recommendations are only directed at improving the present description of fish populations in the Slave River downstream of Fort Smith as far as the Slave River Delta.

One of the strongest recommendations we can make is for a detailed fall study of lake whitefish and inconnu populations in the Slave River near Fort Smith. Because of their large concentrations here, such a study should provide an excellent opportunity to determine first, the importance of the upper Slave River as a lake whitefish and inconnu spawning area, and second, the importance of lake whitefish and inconnu spawning in the Slave River to domestic and commercial fisheries elsewhere. Such a study would also provide valuable information on goldeye, itself a potentially important commercial species and one which is very abundant during the fall near Fort Smith.

Similar studies should also be undertaken on longnose suckers and walleye near Fort Smith during the spring. Instead of restricting this study to the Slave River, however, tributaries such as the Salt River should also be investigated. Quick surveys along the entire length of the Slave River at this time would also be useful in determining spawning times and spawning areas for northern pike.

Large numbers of both burbot and small-bodied ciscos are known to spawn in Resdelta Channel and the lower reaches of the Slave River. The upstream limit of their spawning grounds should be determined during peak spawning periods.

Chapter IX

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DEPARTMENT OF INDIAN AFFAIRS
AND NORTHERN DEVELOPMENT

Northern Affairs Program, Water Resources Division
Yellowknife

D

Assessment of Migratory Bird Resources in the Slave River Delta

Prepared by

R.G. Thomspon
R.W. Quinlan
K. Ambrock

Environment Canada
Canadian Wildlife Service
Edmonton, Alberta

Edmonton, Alberta

December, 1979

EXECUTIVE SUMMARY

As part of the federal-provincial Mackenzie River Basin Study Program, a two-year study of the Slave River Delta, N.W.T. was completed in order to obtain baseline information on the area's migratory bird resources. The study was funded jointly by Department of Indian Affairs and Northern Development and Inland Waters Directorate, Department of Environment.

Aerial and ground surveys of waterfowl, passerines (perching birds), shorebirds, and raptors were conducted during the spring, summer, and fall of 1978, and spring of 1979.

The estimated 1978 duck breeding population of the Slave River Delta was 5,218 pairs or 16.8 pairs per square kilometre. The estimated duck production however was much lower than expected. Only 47 broods (201 ducklings) were counted. Factors affecting production estimates are discussed. Most ducks began incubation between 28 May and 24 June. The main hatching period occurred between 23 June and 17 July. Geese did not breed on the Delta in 1978.

The Slave River Delta is of primary value as a spring and fall migration stop for waterfowl, particularly swans and geese. While duck production and migration (staging) use was low compared to Mills-Beaver Lakes and the Peace-Athabasca Delta, the Slave River Delta was utilized as a staging area by large numbers of Whistling Swans and geese. The Delta was considered to be a component of a much larger staging area extending along the south shore of Great Slave Lake between Fort Resolution, NWT and Talston Bay. The peak number of waterfowl estimated on the Slave River Delta in fall, 1978 was 7,600. Another 7,700 swans

and 4,700 geese were recorded between the Delta and Talston Bay. In the following spring, the south shore of the lake (including the Delta) supported a peak numnber of 21,000 waterfowl consisting of 10,300 geese, 5,400 swans, and 5,300 ducks.

Common passerine birds breeding on the Slave River Delta were Yellow Warbler, Common Snipe, White-throated Sparrow, Tree Sparrow, Least Flycatcher, Yellow-rumped Warbler and Red-eyed Vireo. Colonies of Arctic Terns and California Gulls were located on the sandspits of the "outer delta". Two active Bald Eagle and one active Osprey nests were found. Shorebird use of the Delta was particularly high in the fall when as many as 3,000 individuals were recorded.

In terms of migratory birds the Slave River Delta is important on a local, regional, and international scale. Substantial numbers of migratory game birds are harvested by the residents of Fort Resolution.

The biological productivity of the Slave River Delta is highly dependent on the water regime. Since plant succession, and hence migratory bird utilization is dependent on the timing, magnitude, and duration of flooding, any modifications to existing water regime would have direct effects on the Delta's migratory bird resources.

ACKNOWLEDGEMENTS

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Glen Wakal and Ian Ross, survey pilots with Buffalo Airways Ltd, Fort Smith, were especially appreciated for their skilled flying of survey routes and for their interest in the project. Water Survey of Canada and Northwest Lands and Forest Service, Fort Smith, provided logistical support. Brian Chubb of Canada North Graphics, and Susan Popowich of CWS drafted the figures for the report.

Kevin Menicoche, a summer student employed through the N.W.T. Science Advisory Board, helped to collect field data. Ken Bodden of the University of Alberta, helped solve logistical problems. Cabe Lafferty and the town council of Fort Resolution were appreciated for their cooperation.

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CHAPTER I

INTRODUCTION

> "Recently the Slave River Delta has become recognized as a potentially sensitive and ecologically important area. Located 325 kilometres downstream of the Peace-Athabasca Delta, the Slave River Delta has been formed where the Slave River discharges into Great Slave Lake just 10 kilometres north of the settlement of Fort Resolution. Residents of Fort Resolution rely on the delta to provide a part of their income through the sale of pelts as well as to provide a source of food. The resources upon which the residents rely are themselves dependent on the natural regime of the delta, (Mac. Riv. Basin Com. Study Prog. 1978)."

The Slave River Delta is the only major delta in the Mackenzie River drainage basin between the Peace-Athabasca Delta in northern Alberta and the Mackenzie River Delta in the Northwest Territories. Since it is much smaller than these deltas, the Slave River Delta, until recently, has been overlooked by environmentalists. No previous intensive ornithological studies of the Slave River Delta have been conducted.

In the past, the Slave River was part of the main route used to penetrate Canada's northern frontier. Explorers such as Samuel Hearne, Peter Pond, Alexander Mackenzie, John Franklin, George Back, and other early adventurers passed through this area. However, very little was written about the Slave River Delta. In later years, naturalists such as David Hanbury, J.W. Tyrell, Ernest Thompson Seton, and Edward Preble travelled through the delta on their scientific voyages in the north (Preble 1908). Not until the twentieth century were studies done on the biological resources of the delta itself. J. Dewey Soper, Dominion Wildlife Officer for Alberta and the Territories, conducted most of the investigations at that time.

Soper (1949, 1952a, 1952b, 1957) stated that the delta supported "a substantial waterfowl population". Soper (1952a, 1952b) proposed that the Slave River Delta, together with Egg Island, located off the shore of the delta, be established as bird sanctuaries.

As a result of the Migratory Bird Act of 1917, which created closed hunting seasons and licensed hunting, a portion of the Slave River Lowlands and the Delta was set aside in 1923 as the Slave River Preserve, an area established exclusively for native hunting and trapping. During the following three decades amendments were made in order to allow the resident white population to hunt and trap in the delta. In 1955, the status of the Slave River Delta as a preserve was repealed due to public demand (Hunt 1976).

Although waterfowl production in Canada's boreal forest is not as great as in the prairie pothole region of North America, it is felt that the northern lands of Canada are underestimated for their importance as waterfowl habitat (Welleim and Lumsden 1964; Bellrose 1976). During years of drought on the prairies large numbers of waterfowl move north to the more stable ponds and sloughs in the boreal forest.

River deltas, where large amounts of sediments are deposited annually, represent some of the most biologically productive aquatic and semi-aquatic habitats. Alterations in water regime or water quality can seriously affect the biological productivity of deltas, as documented in the Peace-Athabasca Delta (Townsend 1972). The sensitivity of the Slave River Delta to any changes in the river regime must be considered.

In May of 1978, an inventory of waterfowl and other migratory birds occurring on the Slave River Delta was initiated by the Canadian Wildlife Service. The study was funded jointly by Department of Indian Affairs and Northern Development and Inland Waters Direcorate (DOE) under the auspices of the Mackenzie River Basin Study Program. The goals of the study were:

> "to compile a list of bird species using the area and their relative status, and to document the area's potential for maintaining rare species."
>
> "to document the use of the area by migratory birds during the spring staging, breeding, production and fall staging periods in relation to existing habitat conditions (Mac. Riv. Basin Com. Study Prog. 1978)."

During the summer and fall of 1978, and spring of 1979, aerial surveys were conducted to assess use of the delta by waterfowl. A summer field camp was established on the delta from 12 June to 25 August, to observe and document use of the delta by waterfowl, other water-oriented birds, raptors, passerines, and passerine-like birds. Based on these data and available vegetative and hydrologic information, the relationship between the Delta's migratory bird utilization and hydrologic regime was assessed.

CHAPTER II

DESCRIPTION OF STUDY AREA

A. Location and Physiography

The Slave River Delta (61°15'N lat, 113°40'W long) is located 200 km downstream of Fort Smith on the Slave River (Figure 1). It is situated 2 kilometres northeast of Fort Resolution, at an elevation a few metres higher than that of Great Slave Lake (156 m asl). The area of the delta is 310 km^2.

The Slave River drainage includes a large area of northern British Columbia, Alberta, and Saskatchewan, as well as the Slave River Lowlands in the Northwest Territories. The delta is situated within the Upper Mackenzie Boreal Forest Region (Rowe 1972). This area is characterized by alluvial flats bordered by low benchlands and terraces which grade to undulating terrain with isolated ridges and low hills.

B. Geology, Soils, and Permafrost

The Slave River Delta lies within the Slave River Lowlands, an area designated as a former south arm of Great Slave Lake which was filled in by sedimentation (Day 1972). As the lake receded during the post-glacial period, the Slave River became established. Devonian and Cretaceous bedrock is buried deeply under glacial till and lacustrine and

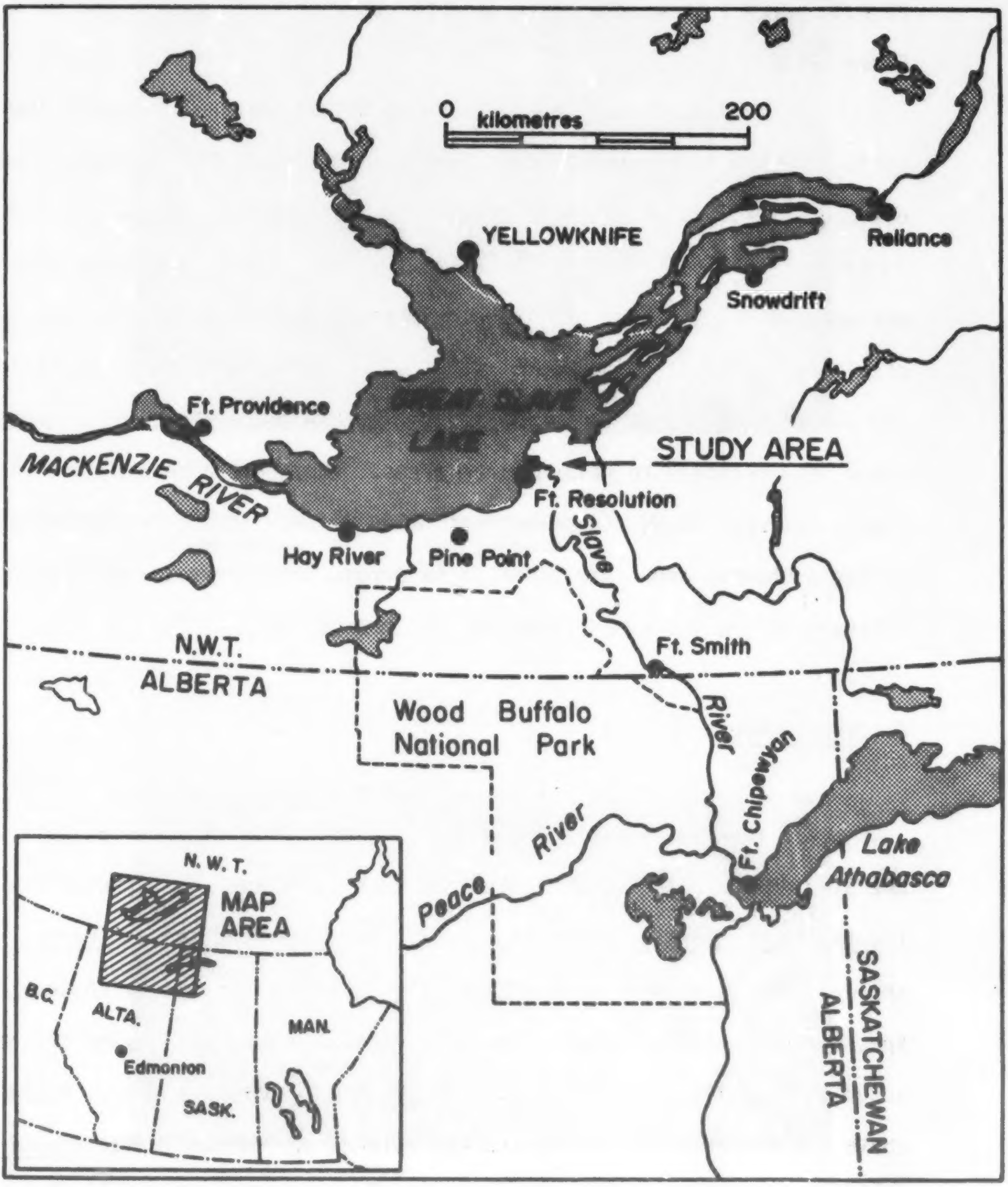

0 kilometres 200
YELLOWKNIFE
Reliance
Snowdrift
GREAT SLAVE LAKE
Ft. Providence
STUDY AREA
MACKENZIE RIVER
Ft. Resolution
Slave
Hay River
Pine Point
N.W.T.
ALBERTA
Ft. Smith
Wood Buffalo National Park
River
Ft. Chipewyan
Peace River
Lake Athabasca
SASKATCHEWAN
ALBERTA
N. W. T.
MAP AREA
B.C.
ALTA.
Edmonton
SASK.
MAN.

Figure I. Location of the study area, 1978/79.

alluvial materials (Rowe 1972). The Precambrian Shield is exposed within 25 kilometres east of the delta at such outcrops as Stoney Island on Great Slave Lake.

The majority of the delta is of the alluvium land type. The soils are Cumulic Regosols, whose composition ranges from a grayish-brown, calcareous, loamy sand to a silty clay loam (Day 1972). These soils occur in siltbars and siltflats of the delta (Plate 1), less than three m above average river level, and are frequently flooded (Day 1972). In more stable parts of the delta, in particular the Nagle Channel area, the Iche and Jerome soil series occur (Day 1972). These are Cryic Cumulic Regosols found in moderately to well-drained areas. They have a thin organic layer over calcareous loam, and permafrost below 80 cm. In poorly drained areas of Nagle Channel and other older delta areas, Rego Cleysols and Rego Humic Celysols of the Taltson soil series are present (Day 1972).

C. Vegetation

Riparian vegetation growing on large areas of alluvial soil in the Slave River Delta is characterized by species such as horsetail (Equisetum fluviatile), cattail (Typha latifolia), and sedges (Carex spp.). The outer portion of the delta is mainly vegetated by these species (Plate 2). In less frequently flooded areas, and beyond the ice scour zone, willows (Salix spp.) predominante (Plates 3 and 4). Higher above the water levels and levees and uplands are balsam poplar (Populus balsamifera), alder (Alnus sp.), and other woodland species. In the more stable localities small stands of white spruce (Picea glauca) and black

Plate 1. Siltbar located near the mouth of Steamboat Channel, Slave River Delta, N.W.T., July 1978.

Plate 2. Mouth of Signal Channel, Slave River Delta, N.W.T., July 1978.

Plate 3. Big Rat Lake, Slave River Delta, N.W.T., July 1978.

Plate 4. Willow Lake, Slave River Delta, N.W.T., July 1978.

spruce (P. *mariana*) occur. Some ponds and perched basins are present, the more isolated ones having a well developed aquatic plant community consisting primarily of pondweed (*Potamogeton* spp.), arrowhead (*Sagittaria* sp.), milfoil (*Myriophyllum* sp.), mare's-tail (*Hippuris* sp.), bladderwort (*Utricularia* sp.), *Rananculus* sp., yellow water-lily (*Nuphar variegatum*), and white water-lily (*Nymphaea tetragona*) (Plates 4 and 5). The shores of these ponds are composed of a floating vegetation mat of sedge and cattail. The shoreline vegetation of the ponds which receives a yearly influx of floodwaters, however, is predominantly horsetail (Plate 6). Aquatic vegetation in the river channels and shallow shoreline waters of Great Slave Lake is poorly developed, although in Nagle Bay and some other shallow areas in the outer delta scattered stands of Richardson's pondweed (*Potamogeton richardsonii*) and bulrush (*Scirpus* sp.) are present. A detailed description of the delta's vegetation is given in English (1979).

D. Climate

The Slave River Delta is located within the sub-arctic climatic zone (Atlas of Can. 1957). This zone is characterized by cold winters. The mean temperature of the coldest month in the sub-arctic zone is below -3°C. Summers are cool and short with only one to three months having a mean temperature above 10°C. In Fort Resolution the mean daily temperature of the coldest month (January) is -26.3°C (Atm. Environ. Serv. 1973a). June (11.8°C), July (15.7°C), and August (14.3°C) have mean daily temperatures above 10°C (Atm. Environ. Serv. 1973a). Mean

Plate 5. Willow Lake, Slave River Delta, N.W.T., July 1978.

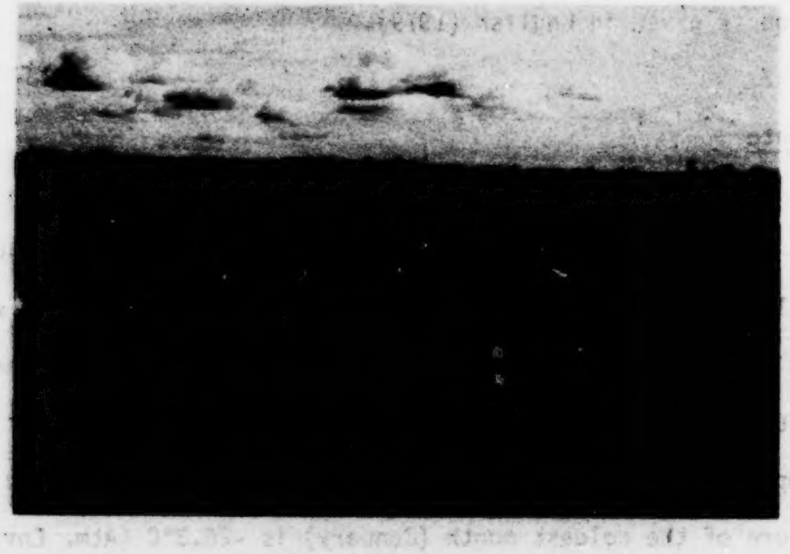


Plate 6. Lake #2, Slave River Delta, N.W.T., July 1978.

total precipitation for Fort Resolution is 28.57 cm (Atm. Environ. Serv. 1973b). The number of days having frost total 227 in Fort Resolution with July and August usually frost-free (Atm. Environ. Serv. 1973b).

E. Hydrology

The water regime of the Slave River is one of the major factors determining the physical and biological characteristics of the Slave River Delta. Spring floods provide deposition of alluvium, dilution of acidic organic compounds, and the filling of perched basins. the fertility of the flood plains is thus maintained, permitting successional plant growth and preventing the establishment of muskeg conditions (Stevens 1971). The slowing down of river water as it reaches Great Slave Lake results in greater deposition of silt. As the sediments continue to be deposited, the delta grows in the direction of the lake. The extent of this growth is determined by the amount of sediment deposited, and by the rate of sediment loss due to wave action and lake currents (Reid and Wood 1976, Bardach 1964).

Frequent spring flooding has resulted in the buildup of levees along major channels. Behind these levees occur alluvial lowlands with occasional oxbow ponds and perched basins, which require spring floods to retain their water levels.

CHAPTER III

WATERFOWL BREEDING, 1978

A. Introduction

In order to estimate the importance of the Slave River Delta as breeding habitat for waterfowl, indicated breeding pair (IBP) surveys were flown during early June.

Previous evaluation of the breeding habitat and its use by waterfowl was described by Soper (1949):

> "Small ponds and lakes, within the limits of the delta, are relatively not nearly as numerous as in either the Athabasca, or Mackenzie Deltas."

Soper (1949) quotes C. Law, then of the Federal Wildlife Division:

> "It is asserted that a fair breeding population of sporting ducks and other wildfowl resorts to the delta. The total per acre, or square mile, however, is relatively paltry as compared with really high-class breeding areas."

In Soper's (1952a) proposal for Slave River Delta bird sanctuary he states:

> "Nevertheless, the waterfowl breeding population is only moderate in size. While numerous species resort to it during the nesting season, the overall aggregate is clearly much smaller per square mile than in either of the two deltas mentioned above [Athabasca and Mackenzie Deltas]."

B. Methods

A reconnaissance survey was flown by K. Ambrock on 23 May 1978, over the "outer delta". The area censused for waterfowl covered approximately 55 kilometres of shoreline. Due to the late breakup on Great Slave Lake, the first breeding pair survey was delayed until 1 June. Subsequent surveys were carried out on 4 June and 7 June. These dates were similar to those of the United States Fish and Wildlife Service (USFWS) waterfowl breeding population surveys in bush transects, which are performed every year during the period 12 May to 12 June (USFWS 1977). The primary criteria used by USFWS for initiation of surveys in bush units are ice breakup, the buildup of representative waterfowl species in traditional breeding areas, and the dispersal of paired waterfowl onto breeding territories. A buildup on breeding pairs, along with apparent absence of spring migrants, was observed by 1 June.

Survey flights were initiated by 0900 and completed by 1100 hrs. On all three surveys, weather conditions were favourable, visibility was good, and winds were light.

Transects were flown at an altitude of 30 to 45 m above ground level (agl). The ground speed did not exceed 160 kmph. Transects were oriented NE to SW except for Transect A which followed the shoreline of the outer region of the delta (Figure 2). All transects, except Transect A, were parallel and located 1.6 km apart on 4 and 7 June, and 8 km apart on 1 June. Seven ponds were also surveyed (Figure 2).

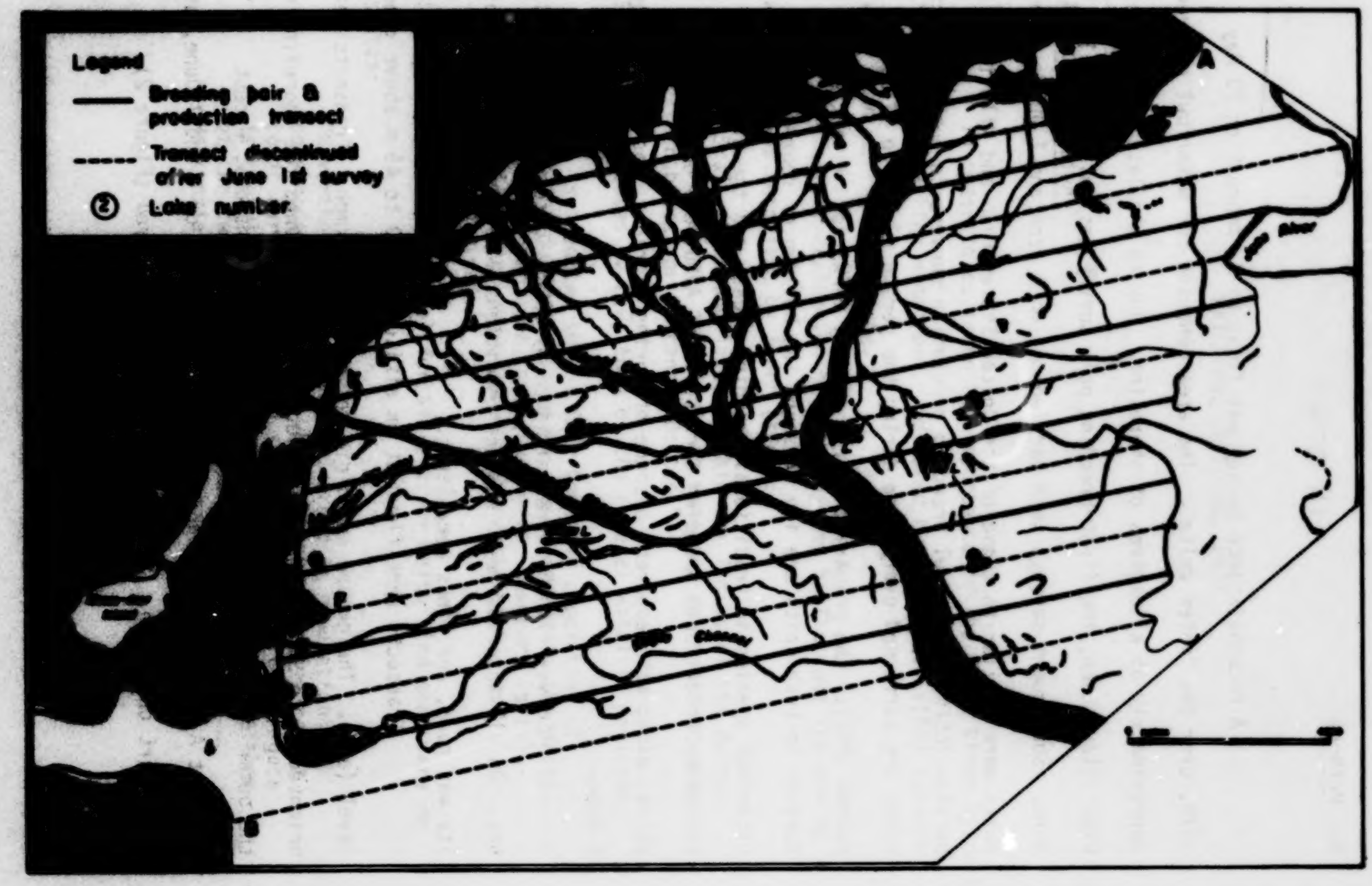

Legend
Breeding pair & production transect
Transect discontinued after June 1st survey
② Lake number
A
River

Figure 2. Locations of breeding pair and production transects and ponds surveyed, Slave River Delta, N.W.T., 1978.

On 1 June, all transects flown were 0.2 km wide with observations restricted to one side of the aircraft only. On the 4 June and 7 June surveys, every second transect was flown (Transects A, C, E, G, I, K, M, O). Observations were made from both sides of the aircraft, providing coverage of a 0.4 km wide strip along each transect. This provided for coverage of 19% (1 June) and 22% (4 and 7 June) of the delta's surface area, respectively. All data were recorded on Sony TC-45 tape recorders and later transcribed onto breeding pair data forms. The data were summarized according to criteria outlined in USFWS Standard Procedures (1977).

C. Results and Discussion

No breeding geese were observed on the delta in 1978. Based on aerial surveys, the estimated duck breeding population was 5,218 pairs (Table 1) or 16.8 pairs/km^2. Dabblers comprised 52% (2,227) of all indicated breeding pairs while divers comprised 48% (2,037). The more common breeders were: Lesser Scaup (768 pairs) followed by Mallard (726 pairs), American Widgeon (494 pairs), Bufflehead (379 pairs), and Blue-winged Teal (221 pairs).

Overall, breeding ducks were distributed relatively uniformly throughout the Delta. The mean number of pairs sighted per km of transect varied from 2.7 on Transect E to 4.0 on Transect G. The mean number of pairs per km for all transects were 3.5. The outer delta, (Transect A) yielded 3.2 pairs per km. There were, however, marked differences in habitat preference by species. Dabblers such as Mallard and Widgeon

Table 1. Duck breeding pair estimates, Slave River Delta, N.W.T., 1978.

Species	Optimum census date	Number of pairs*	Density
Mallard	June 1	726	$2.3/km^2$
Pintail	June 7	77	$0.2/km^2$
Gadwall	June 4	41	$0.1/km^2$
American widgeon	June 1	494	$1.6/km^2$
Shoveler	June 7	100	$0.3/km^2$
Blue-winged teal	June 1	221	$0.7/km^2$
Green-winged teal	June 1	42	$0.1/km^2$
Teal sp.	June 1	205	$0.7/km^2$
Unid. dabbler	June 1	321	$1.0/km^2$
Total dabbler		2227	$7.1/km^2$
Scaup	June 1	768	$2.5/km^2$
Ring-necked duck	June 1	37	$0.1/km^2$
Redhead	June 4	23	$0.1/km^2$
Canvasback	June 4	109	$0.4/km^2$
Goldeneye sp.	June 4	82	$0.3/km^2$
Bufflehead	June 1	379	$1.2/km^2$
Ruddy duck	June 7	50	$0.2/km^2$
White-winged scoter	June 7	5	$0.1/km^2$
Surf. scoter	June 4	32	$0.1/km^2$
Scoter sp.	June 1	5	$0.1/km^2$
Unid. diver	June 1	547	$1.8/km^2$
Total divers		2037	$6.9/km^2$
Unid. ducks	June 1	952	$3.1/km^2$
Total ducks		5216	$16.8/km^2$

* Estimates for entire delta based on percentage of area sampled (see Appendices - Table A-2).

tended to prefer the outer, less stable portion of the Delta while divers such as the Bufflehead and Ring-necked duck preferred the inner, more stable, boreal-type ponds.

The results of surveys on the Slave River Delta cannot be validly compared to those of other areas studied (eg. Peace-Athabasca Delta) because of variations in survey techniques, weather, timing, observer efficiency, etc. However, some general inferences can be made regarding the relative value of the Slave River Delta as a waterfowl breeding area. The Delta does not appear to support the high breeding duck utilization recorded in the parklands of Alberta where densities of up to 116 pairs per km^2 (compared to 16.8 pairs/km^2 in the Slave River Delta) have been observed (Turner and Weaver 1978). On the other hand, breeding pair densities estimated in the Peace-Athabasca Delta for the period, 1971 to 1976 (Hennan 1972, 1974, 1975; Hennan and Ambrock 1977), are similar, on the average, to those obtained for the Slave River Delta. The Slave River Delta is much smaller than the Peace-Athabasca Delta (310 km^2 compared to 3820 km^2) and, as such, its overall contribution as a breeding area is understandably lower. It should be noted that the Slave River Delta nevertheless represents a small area of relatively good breeding habitat in comparison to the surrounding boreal forest. It should also be noted that further inferences cannot be drawn based on only a single year of survey data.

CHAPTER IV

WATERFOWL PRODUCTION, 1978

A. Introduction

Although breeding pair and brood surveys are useful in assessing the value of habitat for waterfowl, brood surveys are a more direct measurement of productivity. Brood surveys include only those birds that nest in the study area, whereas breeding pair surveys include birds that may disperse to other areas to raise young.

As stated previously, the Slave River Delta is not considered to be a highly productive area for waterfowl in comparison to other major deltas. Although waterfowl densities of the woodlands and tundra are comparatively low, waterfowl habitat (i.e. ponds and streams) is much more stable in Canada's north than in the prairie pothole area of central North America. This northern habitat is not subjected to the occasional drought which occurs in the prairies. Thus the importance of the north to waterfowl production becomes greater during dry years on the prairies.

B. Methods

Production surveys were flown on 18 and 27 July, and 11 August. Surveys commenced between 0730 and 0900 hours and ended by about 1000 hours. The first survey was flown primarily to determine dabbling duck production, while the 27 July survey was flown to assess diving duck production which normally occurs later (Hochbaum 1944). The 11 August survey was flown in order to determine production of re-nesting or late nesting birds. The first survey was flown in a Bell 206B helicopter, but the second and third surveys were flown in a fixed-wing Cessna 185. Financial constraints necessitated the use of a fixed-wing aircraft.

The helicopter survey was flown at 30 m agl and 80 kmph. The fixed-wing surveys were flown at the same altitude but at speeds up to 160 kmph. Surveys were flown along the same routes as the second and third breeding pair surveys (Figure 2).

Broods sighted from the air were counted and identified according to species and assigned to age classes (Gollop and Marshall 1954). Because two different types of aircraft were used, no comparisons between the first and subsequent surveys were made.

Two different enumeration techniques were used on each survey. One was to determine the density of broods along the transects; the other to determine the density of broods along the shorelines of the seven ponds. Transects flown covered an area of 67.7 km^2, while 16.5 km of pond shoreline were surveyed.

Ground truthing of four ponds (Willow Lake, Noel Yellie Lake, Big Rat Lake, and Lake #2) was conducted in conjunction with each survey flight.

Data from surveys and incidental sightings were used to back-date broods in order to determine dates of incubation and hatching (Gallop and Marshall 1954).

C. Results and Discussion

Forty-seven broods and 201 ducklings were observed during the first production survey, on 18 July (Table 2). Based on the percentage of the area sampled, the estimated production for the delta was 123 broods and 495 ducklings. The average brood size for all ducks was 4.3 ducklings. On the second survey, 23 broods (90 ducklings) were recorded, while on the third survey 12 broods (41 ducklings) were sighted. Numbers of moulting ducks on the first, second and third surveys were 588, 469 and 1,632, respectively., On all three surveys, dabbler broods accounted for between 65 and 73% of all broods sighted, while the diver component approximated 25 to 30% of all broods counted. The most common dabbler species produced on the delta were Teal sp., American Widgeon, and Mallard; common diver species were Bufflehead, Scaup sp., Goldeneye sp., and Canvasback.

Highest brood densities (Table 3) were recorded on lakes having heavily vegetated shorelines and relatively stable water supplies. While breeding pairs of waterfowl tended to be distributed randomly throughout the Delta, hens with broods, not surprisingly, depended on the more permanent water bodies for cover and food. The results support those found by Nieman and Dirschl (1973) on the Peace-Athabasca Delta. They found that dabbler breeding pairs were attracted to shallow lakes, perched basins and small streams with adequate emergent cover whereas potholes and lakes with relatively stable water levels were required for brood rearing. Diver breeding pairs, on the other hand, preferred larger lakes and deep, slow-moving streams as did hens with broods.

Table 2. Results of waterfowl production surveys conducted on the Slave River Delta, N.W.T., 1978.

Date	Dabblers		Divers		Unidentified		Total Ducks	
	Broods (young)	Mean brood size	Broods (young)	Mean brood size	Broods (young)	Mean brood size	Broods (young)	Mean brood size
18 July (B206)	34(141)	4.1	12(58)	4.8	1(2)	2.0	47(201)	4.3
27 July (C185)	15(63)	4.2	7(24)	3.4	1(3)	3.0	23(90)	3.9
11 August (C185)	8(29)	3.6	3(11)	3.7	1(1)	1.0	12(41)	3.4
				Number of Moulters				
18 July (B206)	277		209		102		588	
27 July (C185)	190		132		147		469	
11 August (C185)	653		112		867		1632	

Table 3. Brood densities, Slave River Delta, N.W.T., 1978.

	Dabblers	Divers	Unid. Ducks	Total ducks
July 18 (B206)				
Transects				
Total broods/67.7 sq km	19	7	1	27
broods/ 1.0 sq km	.3	.1	.1	.4
Lakes				
Total broods/16.47 km of shoreline	15	5		20
broods/ 1.00 km of shoreline	.9	.3		1.2
July 27 (C185)				
Transects				
Total broods/67.7 sq km	14	6	1	2
broods/ 1.0 sq km	.2	.1	.1	.3
Lakes				
Total broods/16.47 km of shoreline	1	1		2
broods/ 1.00 km of shoreline	.1	.1		.1
August 11 (C185)				
Transects				
Total broods/67.7 sq km	8	3	1	12
broods/ 1.0 sq km	.1	.1	.1	.2
Lakes				
	NO BROODS			

Most ponds on the Slave River Delta were surrounded by relatively homogeneous habitat consisting of horsetail. Only a few ponds, such as Willow Lake, had a more diverse community structure with shorelines of boreal forest, willow and cattail. These areas tended to provide more diverse cover and food for ducklings. Overall, there were no major differences in brood production between transects. The "outer delta" was utilized more by moulters, but not preferred over the "inner delta" by broods. There were, however, variations in brood cover preferences between species. For example, Bufflehead and Goldeneye tended to prefer ponds with wooded shorelines in the coniferous portion of the Delta.

Based on the earlier breeding pair surveys, the total number of ducklings recorded on all three production surveys was much lower than expected. This discrepancy was probably the result of several factors:

1) counts were extremely conservative due to the inefficiencies inherent in aerial surveys, particularly over heavily-vegetated areas;
2) breeding pairs of waterfowl dispersed from the Delta prior to nesting. It is possible that the Delta provided the last migration stop for waterfowl breeding in the general area but not in the Delta itself;
3) water conditions in the Delta were not condusive to optimum production. Water levels were considered low on the Delta in 1978;

4) the delay of spring migration into the Delta as a result of late break-up may have affected the reproductive success of late nesters or re-nesters.

In any event the production figures obtained for the Slave River Delta in 1978 were felt to be very conservative. For reasons noted above these data cannot be validly compared to the results of other studies conducted in the boreal forest. Superficially, however, brood densities obtained in the Slave River Delta were similar to those found at Utikuma Lake, Alberta (Donaghey 1974) and Mills-Beaver Lakes, N.W.T. (Kemper et al. 1975). It should be noted that, according to local residents, Delta waterfowl populations in 1978 were lower than normal. Habitat conditions in prairie Canada were more favourable for waterfowl, perhaps indicating that fewer ducks overflew the prairie pothole region in 1978.

By backdating the broods of known age-classes it was determined that most species of ducks began incubation between 28 May and 24 June (Figure 3). The main hatch on the delta was between 23 June and 17 July (Figure 3). Murdy (1965) estimated species hatching dates for the Yellowknife area. Murdy's dates for the mean hatching periods of American Widgeon, Mallard and Teal sp. were ten days to two weeks earlier than those obtained for the Slave River Delta. This variation is attributed to the late spring which forced the dabbling ducks to delay nesting. As a result, dabblers and divers (which are normally later nesters) nested at approximately the same time.

Backdating is based on the assumptions that: all broods have been identified correctly; broods are at the mid-point within the plumage

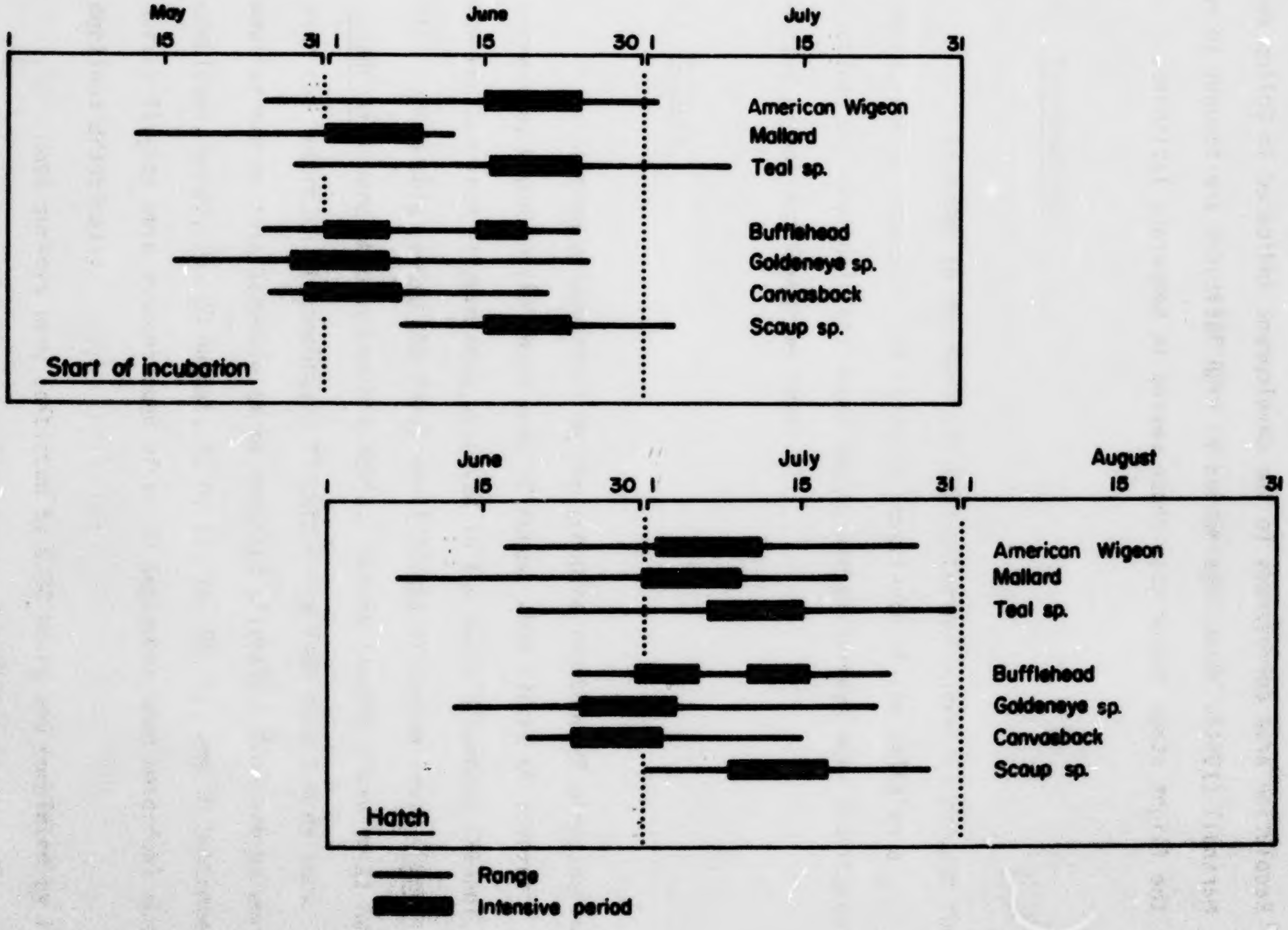


Figure 3. Dates of start of incubation and of hatch for waterfowl found nesting on the Slave River Delta, N.W.T., 1978.

subclass; and development of ducklings to the flying stage in the Fort Resolution area corresponds to the development indicated in Gollop and Marshall (1954). Ducklings reared in high latitudes are thought to reach the flight stage faster than those reared in temperate latitudes.

CHAPTER V

WATERFOWL FALL MIGRATION, 1978

A. Introduction

In order to document the fall waterfowl migration through the delta, and to determine the relative importance of the delta on a continental, regional, and local basis, aerial surveys were undertaken during August and September 1978.

B. Methods

Staging of waterfowl or the grouping together of birds during migration, began in the third week of August when flocks of several hundred American Widgeon were observed in the outer Steamboat Channel area. Also during this period the first small flocks of Canada Geese (Branta canadensis) were observed on the delta. Survey flights began on 21 August, with the intention of conducting flights every four days thereafter. Weather caused this schedule to be modified slightly. Ten surveys were completed, on 21, 25, 28 August, 2, 6, 11, 16, 23, 26, and 30 September Survey flights were discontinued after 30 September when waterfowl numbers declined drastically.

Most surveys were initiated by 0930 hours and completed by 1130 hours. Weather conditions and hence efficiency of observation, were variable on the surveys.

As in the breeding pair surveys, transects were flown at an altitude of 30 to 45 m agl and at speeds not exceeding 160 kmph. Transect A, along the "outer delta", was flown, as well as major channels including Res-Delta ("Big Slave"), East, Middle, Signal, 4-ways, and Steamboat channels (Figure 2). In addition, the seven lakes surveyed for breeding pairs and broods were surveyed during fall migration.

Transect A was the only transect on which a 0.4 km wide survey strip was maintained. The remaining transects followed river channels rather than straight lines. On large channels the aircraft was flown along the centre of the channel and waterfowl were counted on each side, whereas the narrower channels were surveyed from one side only.

C. Results and Discussion

Fall migration data have been presented as the total number of waterfowl counted (Table 4, Figure 4). Total numbers of waterfowl were highest on 16 September (7,634). Ducks numbers peaked on 16 September (3,957). Between 21 August and 11 September, fall migrating ducks were mainly dabblers. The number of diving ducks increased from 155 to 1,058 between 11 September and 16 September, whereas dabbler numbers remained relatively stable (1,413 on 11 September, 1,569 on 16 September). Common duck species during the survey period were American Widgeon, Mallard, Teal sp., and Goldeneye sp.

Most geese observed were Canada geese. Goose numbers peaked on 11 September (2,147) and 16 September (2,169). White geese were observed in a bay to the northeast of the delta on 16 September. No White-fronted

Table 4. Estimated numbers of ducks, geese, and swans recorded during fall aerial surveys, Slave River Delta, N.W.T., 1978.

Date	Number of Ducks	 Geese	 Swans	Total No. of Waterfowl
21 August	1,923	29	0	1,952
25 August	3,016	122	0	3,138
28 August	2,094	310	0	2,404
2 September	2,326	214	7	2,547
6 September	2,478	425	49	2,952
11 September	2,053	2,147	536	4,736
16 September	3,957	2,169	1,508	7,634
23 September	1,670	423	1,799	3,892
26 September	1,215	0	210	1,425
30 September	547	1	108	656

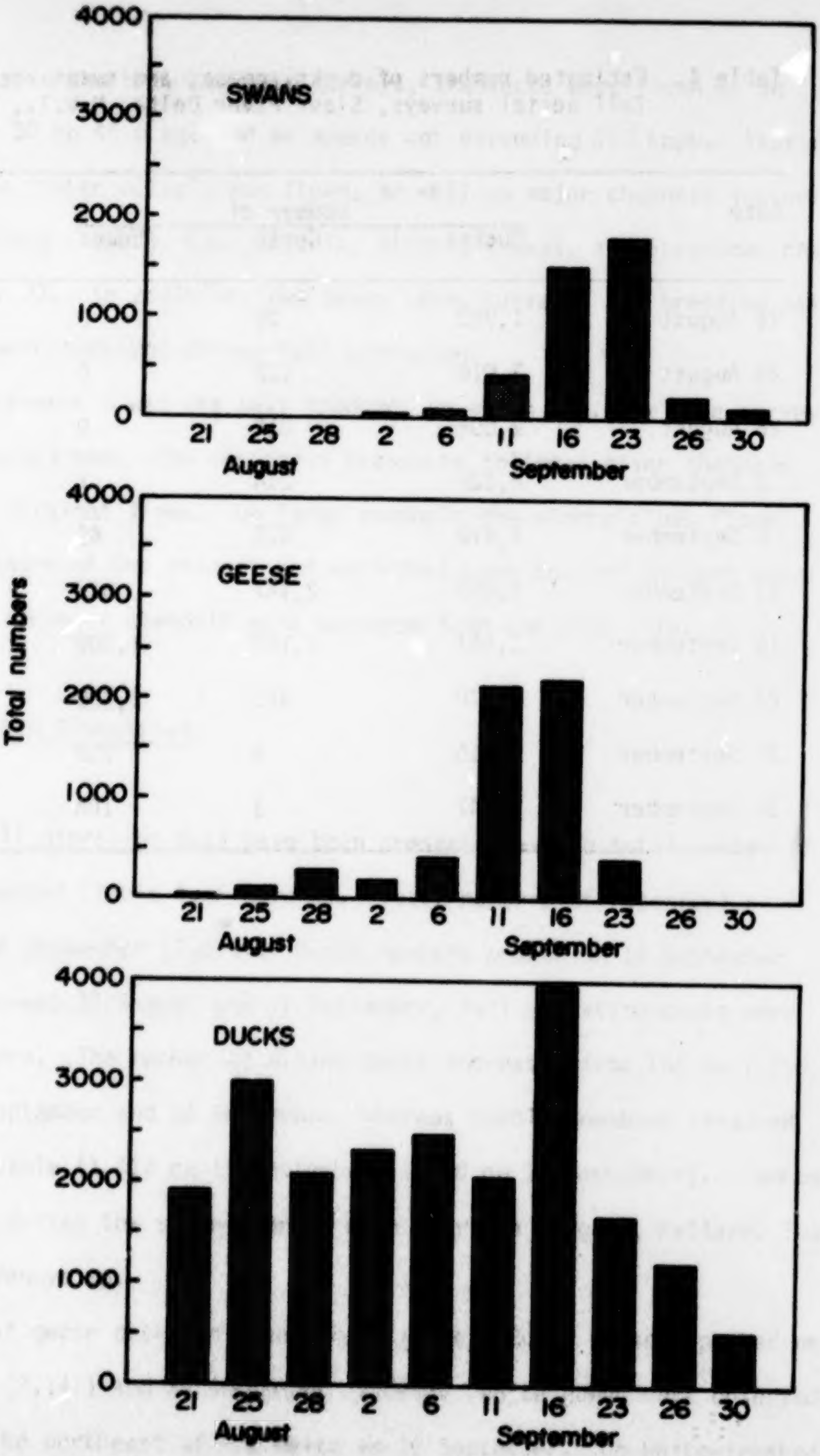


Figure 4. Estimated numbers of ducks, geese, and swans recorded during fall aerial surveys, Slave River Delta, N.W.T., 1978

Geese (Anser albifrons) were sighted. All swans were presumed to be Whistling Swans (Olor columbianus). Swan numbers peaked on 23 September (1,799). During the later part of the swan migration, immature birds were noted. This indicated that breeding swans, which leave their nesting grounds last, were passing through the delta.

Since the areas of major concentration of waterfowl on the delta were surveyed, it is assumed that most of the waterfowl present on the delta were included in the estimates. This was the case for geese and swans, which preferred the "outer delta" and silt bars on the inner channels. For ducks, however, the numbers are undoubtedly conservative as numerous small ponds, snyes, and oxbows not included in the census contained small groups of ducks.

The relative importance of the Delta from a regional standpoint might be indicated by comparison to the Mills-Beaver Lakes area, N.W.T. Canadian Wildlife Service (Karasiuk 1977) conducted aerial surveys of the Mills-Beaver Lakes area at approximately the same period that surveys were flown on the Slave River Delta in 1978. Although direct comparison may not be valid because of the many differing factors which affected each series of surveys, it does give an idea of the relative degree of utilization of the two regions. The Slave River Delta is of moderately low importance as a staging area to migrating ducks compared to the Mills-Beaver Lakes area (Figure 5). In terms of utilization by geese the Delta is more prominant, although it still does not support the numbers of the Mills-Beaver Lakes area (Figure 6). Swan numbers however were higher throughout September in the Slave River Delta (Figure 7). In the Mills-Beaver Lakes area there was a large increase in swan numbers on the 6 October survey.

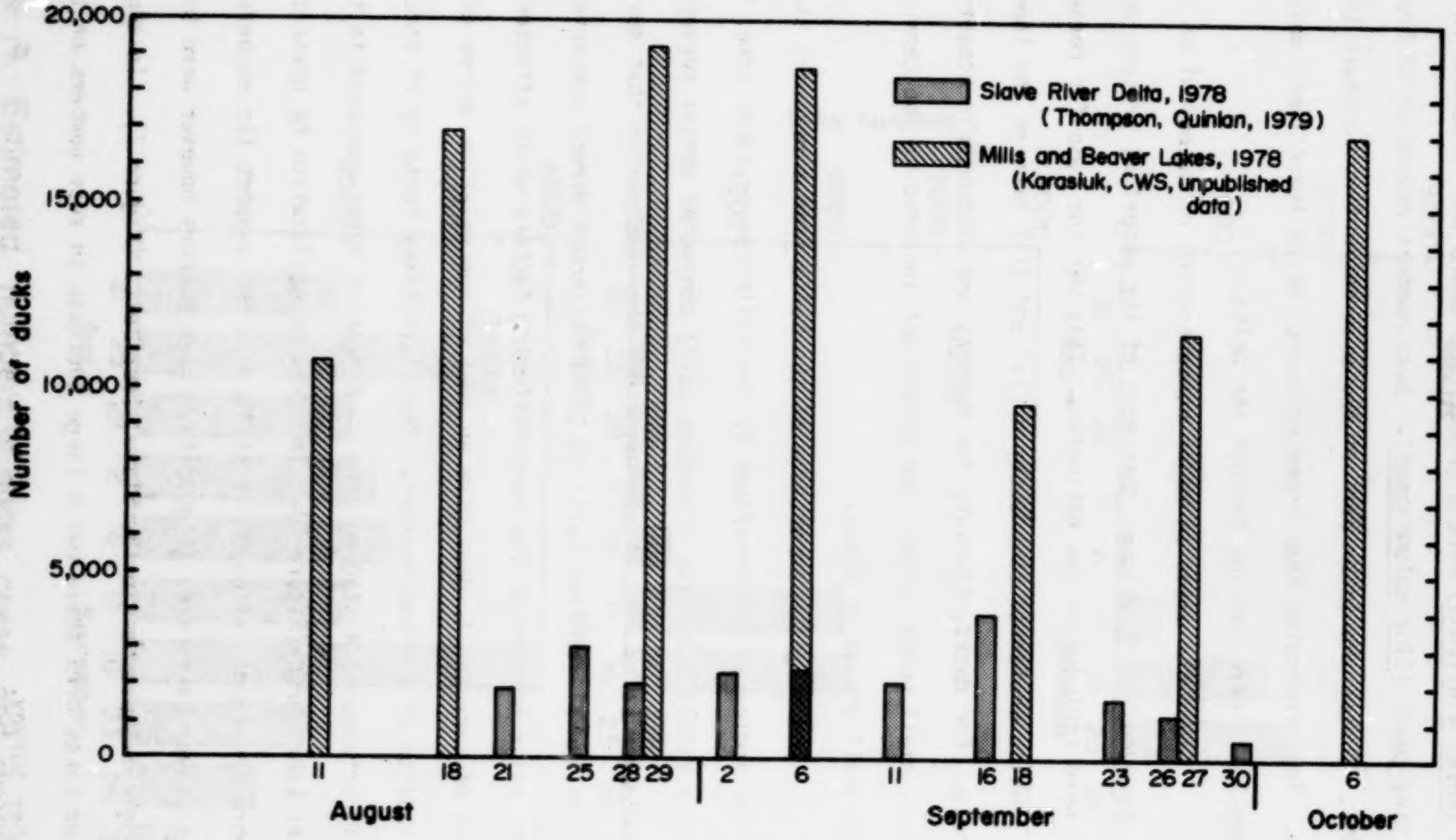


Figure 5. Estimated number of ducks observed on fall aerial surveys, Slave River Delta and the Mills-Beaver Lakes, N.W.T., 1978.

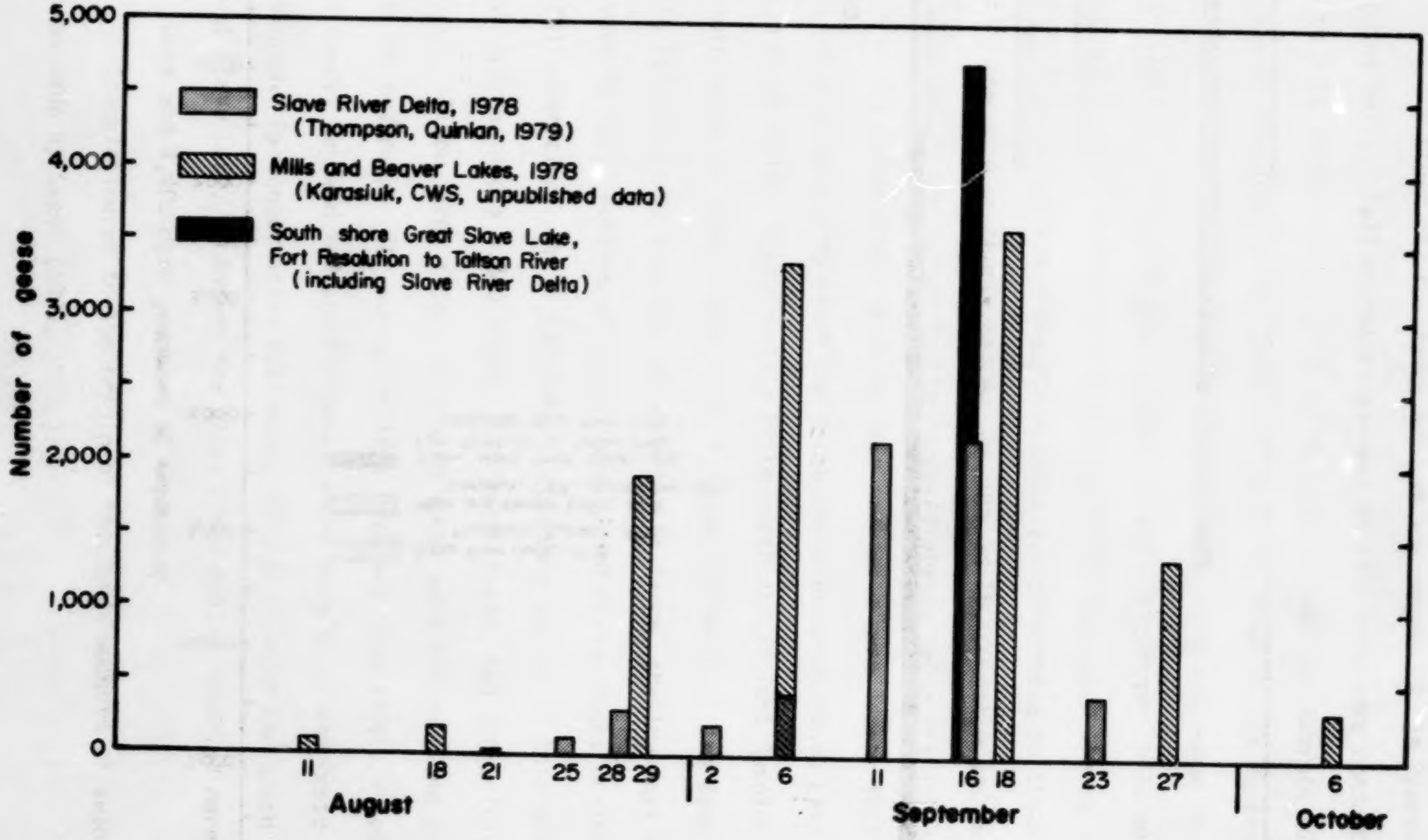


Figure 6. Estimated number of geese observed on fall aerial surveys, Slave River Delta, the "south shore" of Great Slave Lake, the Mills-Beaver Lake, N.W.T., 1978.

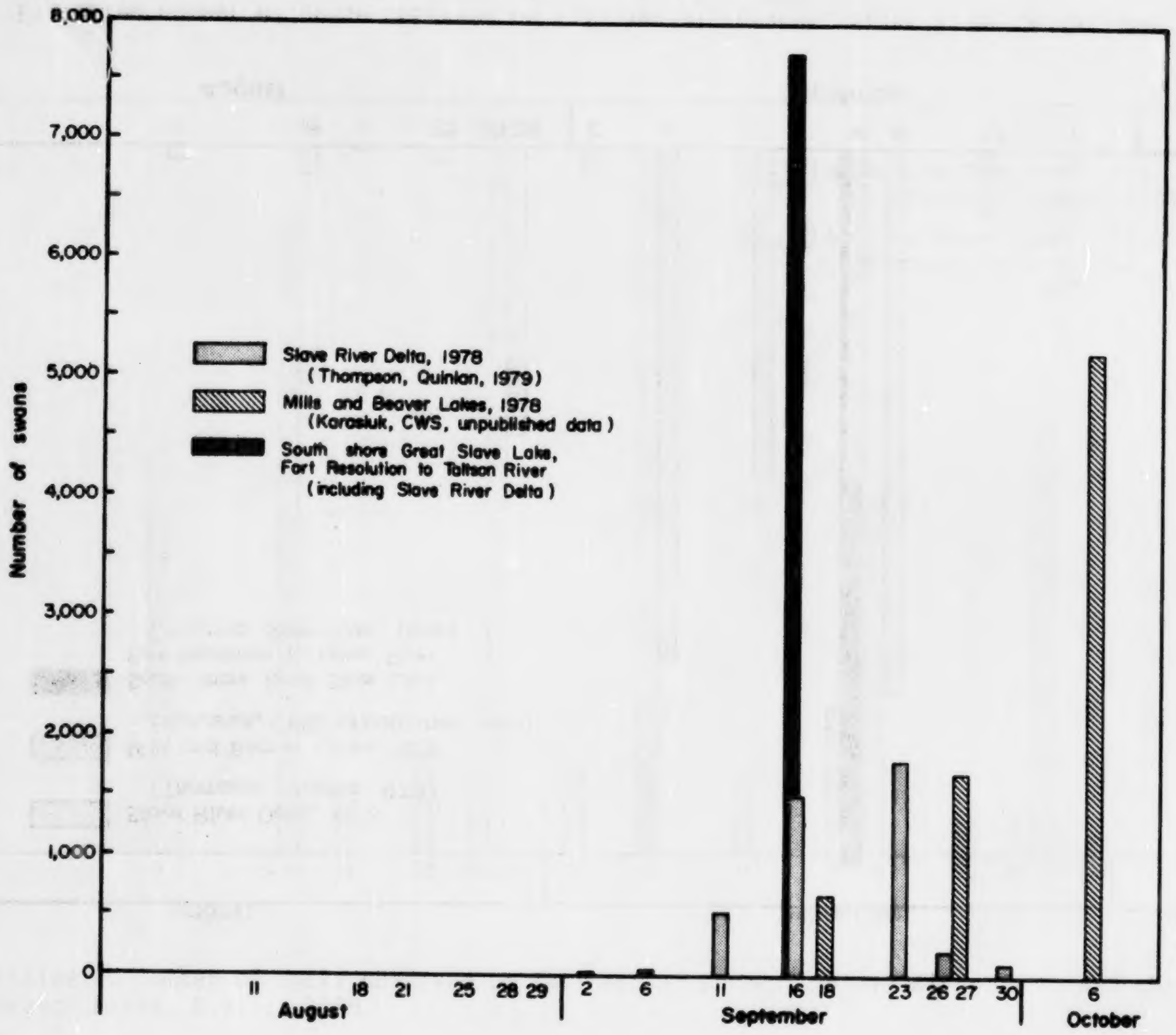


Figure 7. Estimated number of swans observed on fall aerial surveys, Slave River Delta, the "south shore" of Great Slave Lake, and the Mills-Beaver Lake, N.W.T., 1978.

The other major staging area in the region is the Peace-Athabasca Delta. Fall migration surveys in this area were conducted from 1971 to 1976 (Hennan 1972, 1973, 1974, 1975; Hennan and Ambrock 1977). Duck use of the Slave River Delta was much less than in the Peace-Athabasca Delta, where as many as 106,200 ducks have been seen in a single survey (1971). Goose and swan numbers in the Slave River Delta were approximately half of the Peace-Athabasca Delta average numbers, although the 1978 figures for the Slave River Delta are comparable to those of low years in the more southerly delta. As many as 16,500 geese and swans have been observed in one survey in the Peace-Athabasca Delta (in 1972).

The Slave River Delta is only part of a much larger fall migration area extending along the south shore of Great Slave Lake to the Taltson River Delta, approximately 80 km northeast of Fort Resolution. The south shore of Great Slave Lake, between the mouth of the Jean River, and the Taltson River consists of a series of large, shallow bays which were used by large numbers of geese, swans, and diving ducks during the 1978 fall migration. On 16 September, a cursory survey of this area was flown. Approximately 6,200 swans, 2,200 dark geese, and 350 white geese were seen. A few large flocks of diving ducks were present, one consisting of 700 Scaup sp. The survey of this area was incomplete, especially in the Gaudet Bay and Taltson Bay areas where many swans and geese were not counted. By conservative estimates, this section of the south shore of Great Slave Lake, including the Slave River Delta supported more than 7,700 swans and 4,400 dark geese on 16 September.

Speculation as to the origin of the large numbers of swans and geese was made by Soper (1949, 1952b):

> "During the autumn migration the birds evidently funnel into the delta from a wide area to the northward, some of them, ostensibly, coming from the mainland arctic coast and perhaps Victoria Island."
>
> "The delta lies in a principal migration route along, or near, Slave River between the noted Peace-Athabasca Delta and points to the northward in the Mackenzie District."

In conclusion, the Slave River Delta is best considered as a component of a larger fall staging area, occurring along the south shore of Great Slave Lake. When considered as a whole, this staging area may be comparable to Mills-Beaver Lakes in utilization by geese, and equal to or greater than Mills-Beaver Lakes in utilization by swans.

CHAPTER VI

WATERFOWL SPRING MIGRATION, 1979

A. Introduction

In year two of the study, aerial surveys were conducted over the Slave River Delta and a section of the south shore of Great Slave Lake to determine the use of the area by ducks, geese, and swans during spring migration. Due to a very late spring there was no open water in Slave River Delta until May 14, 1979. Breakup did not occur until the 21 or 22 of May, 1979.

B. Methods

Aerial survey techniques were similar to those used during the fall migration surveys. However, the routes flown were altered, where necessary, to correspond to the progression of spring breakup. The 14 May survey transects were similar to transects flown in the fall surveys of 1978. On 17 May an additional transect was flown, approximately 0.4 km inside Transect A. On 25 May the flights along channels were discontinued because very few waterfowl were using these areas for staging. By this time the ice on Great Slave Lake deteriorated to the extent that a lead of open water was present along the shoreline. Surveys were then initiated along the south shore from the Jean River to Taltson Bay (Figure 8).

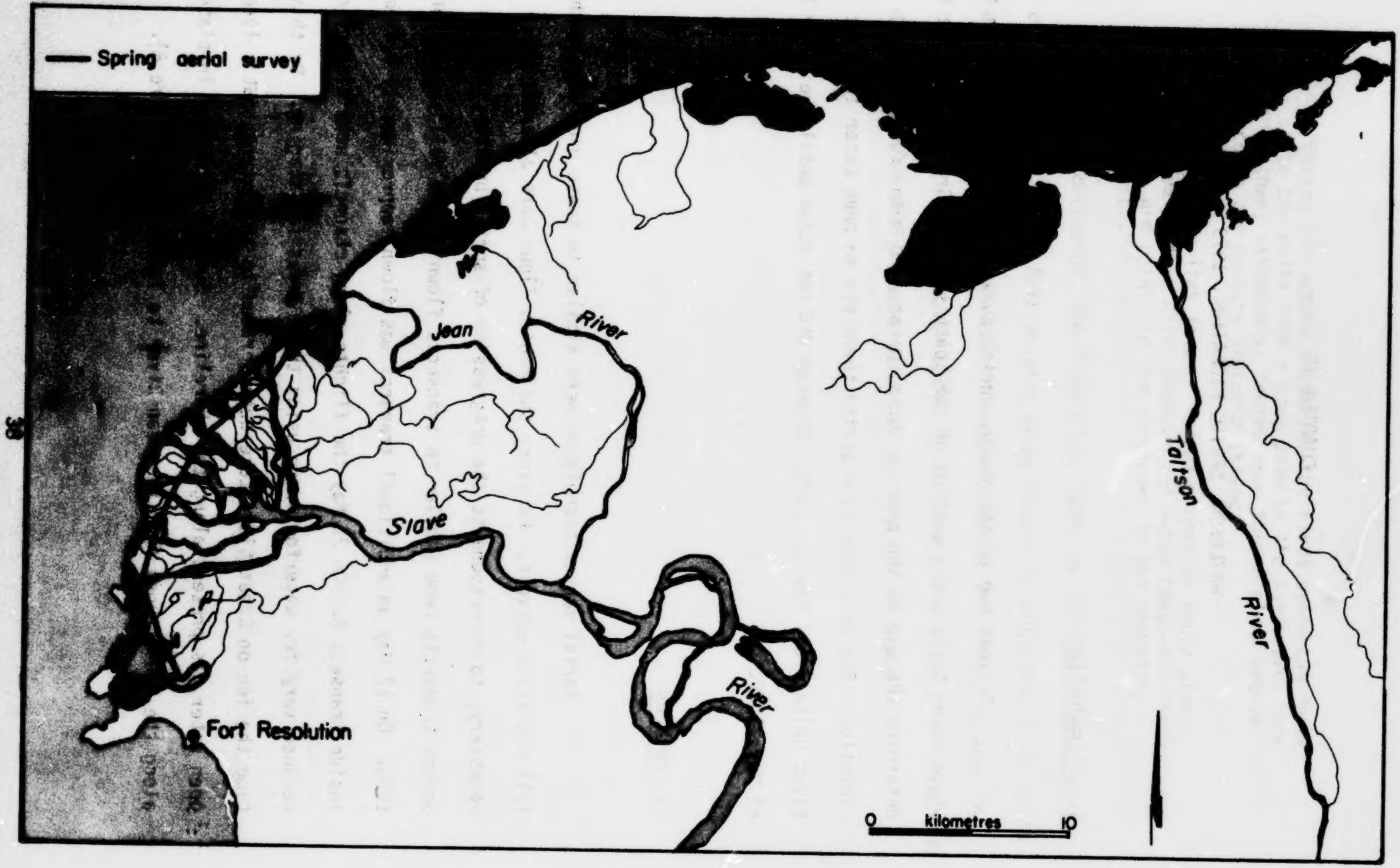

Spring aerial survey
Jean River
Slave River
Taltson River
Fort Resolution
0 kilometres 10

Figure 8. Location of spring aerial survey, south shore of Great Slave Lake, N.W.T., 1979.

Survey flights were undertaken on 9, 14, 17, 20, 22, 24, 25, 30 May and 2 June. On the 24 May survey, heavy fog prevented a survey of the Slave River Delta, and the area censused was restricted to the Jean River-Talston Bay area. By 2 June a noticeable drop in numbers of migrants was observed and survey flights were therefore discontinued.

C. Results and Discussion

Spring migration data have been presented as total numbers of waterfowl counted (Tables 5, 6 and Figures 9, 10). No waterfowl were seen on the 9 May survey. No open water on the delta existed at that time. Peak numbers of waterfowl on the Slave River Delta occurred on 20 May (5,674). Duck numbers peaked on 14 May (3,435) when the first open water was observed. American Widgeon, Mallard, and Scaup sp. were the most numerous spring migrants. Goose numbers peaked on 20 May (3,715), just before Slave River breakup. An estimated 3,265 dark geese and 450 white geese were observed on this date. Swan numbers increased steadily to a peak of 1,339 on 30 May. Swans staged over a longer period than geese with small numbers using the first available water. The peak occurred after the delta was free of ice.

The greatest numbers of ducks, most of which were dabblers, used the first open water on 14 May (Figure 9). The largest numbers of divers however (1,313 Scaup sp.) were present on 30 May.

The use of the Delta habitats by waterfowl varied with the appearance of open water. On the early surveys, waterfowl were found to be using any lakes and protected areas of the outer delta. Geese and swans showed preference for the outer delta at all times.

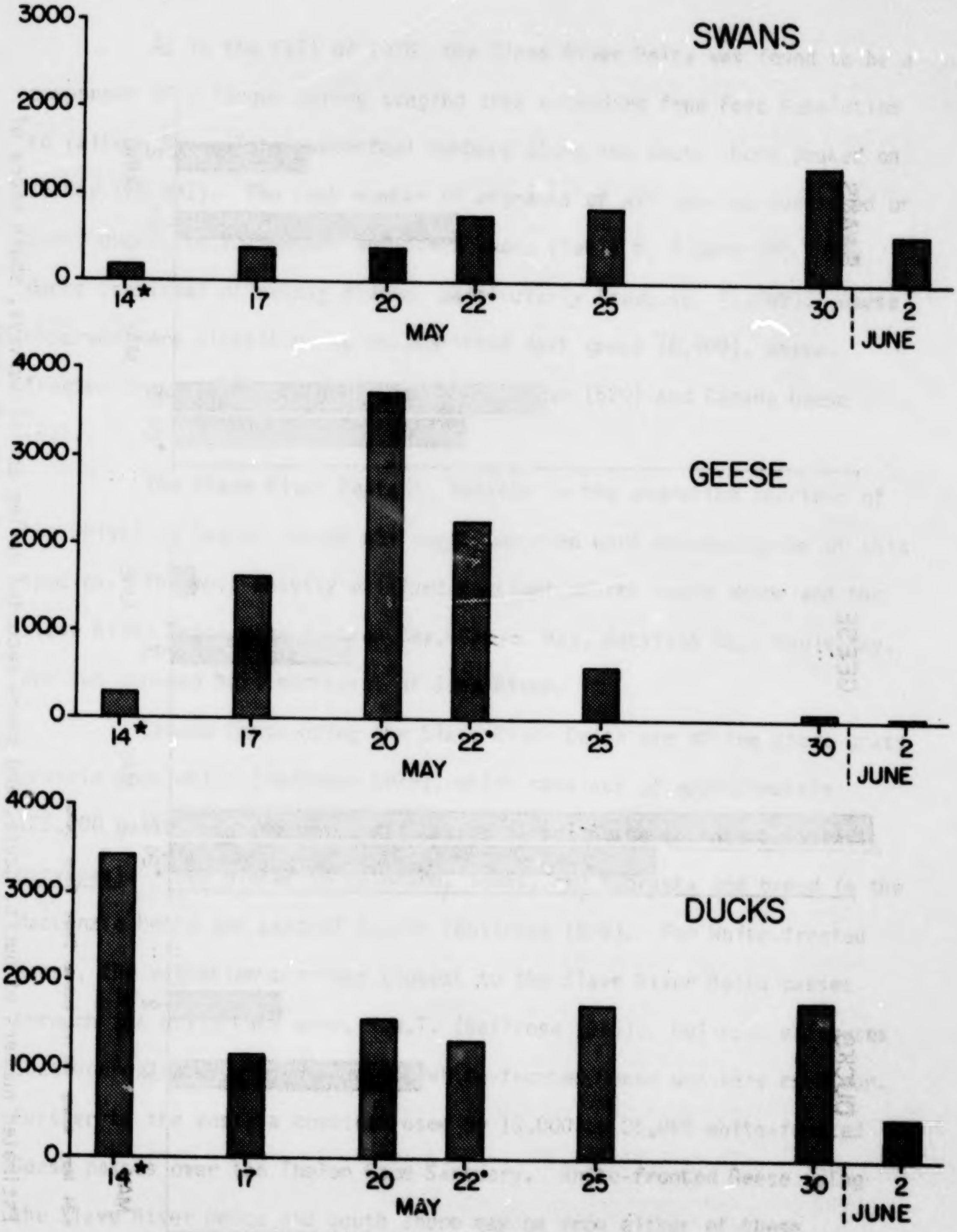
Table 5. Estimated numbers of ducks, geese, and swans recorded during spring aerial surveys, Slave River Delta, N.W.T., 1979.

Date	Number of Ducks	Number of Geese	Number of Swans	Total No. of Waterfowl
14 May	3435	292	174	3901
17 May	1166	1607	386	3159
20 May	1569	3715	390	5674
22 May	1320	2255	752	4327
25 May	1724	593	837	3154
30 May	1779	75	1339	3193
2 June	472	17	548	1037

Table 6. Estimated numbers of ducks, geese, and swans recorded during spring aerial surveys, south shore of Great Slave Lake (Slave River Delta to Taltson Bay inclusive) N.W.T., 1979.

Date	Number of Ducks	Number of Geese	Number of Swans	Total No. of Waterfowl
25 May*	3161	7060	4250	14471
25 May	5319	10257	5405	20981
30 May	3705	2620	4100	10425
2 June	1630	327	1931	3888

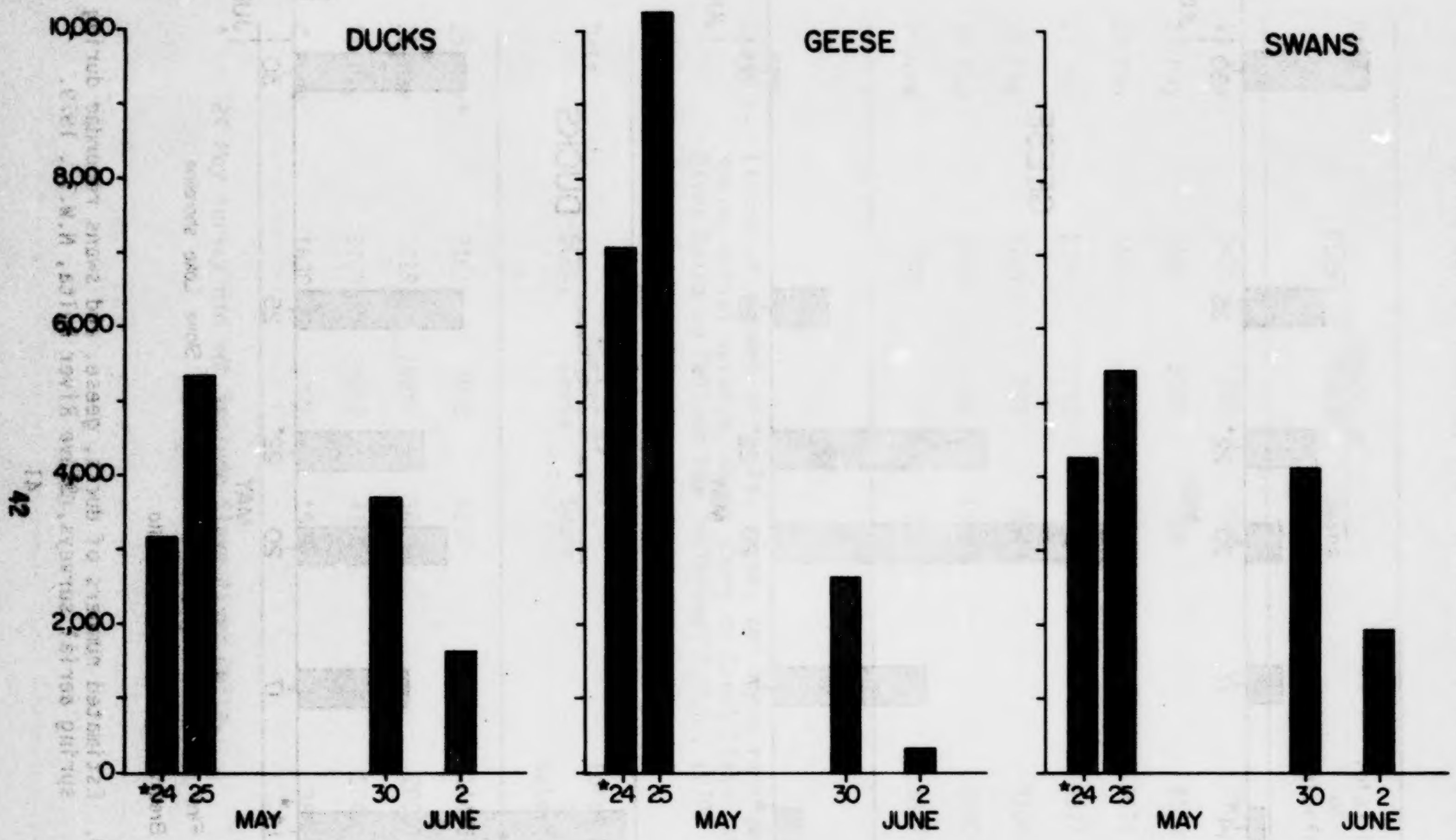
* 24 May survey did not include Slave River Delta.



* First open water along channels and Great Slave Lake shoreline.

• Breakup on Slave River Delta.

Figure 9. Estimated numbers of ducks, geese, and swans recorded during spring aerial surveys, Slave River Delta, N.W.T., 1979.



*24 May survey did not include Slave River Delta.

Figure 10. Estimated numbers of ducks, geese, and swans recorded during aerial surveys, south shore of Great Slave Lake, Slave River Delta to Taltson Bay inclusive, N.W.T., 1979.

As in the fall of 1978, the Slave River Delta was found to be a component of a larger spring staging area extending from Fort Resolution to Taltson Bay. Total waterfowl numbers along the south shore peaked on 25 May (20,981). The peak number of migrants of all species consisted of 5,319 ducks, 10,257 geese, and 5,405 swans (Table 6, Figure 10). The ducks consisted of mainly divers, particularly Scaup sp. (1,989). Geese observed were classified as unidentified dark geese (8,409), White-fronted Geese (602), unidentified white geese (520) and Canada Geese (83).

The Slave River Delta is located in the migration corridor of the Whistling Swans. Hence all swans recorded were assumed to be of this species. The most heavily utilized sections of the south shore and the Slave River Delta were Taltson Bay, Gaudet Bay, Jackfish Bay, Nagle Bay, and two unnamed bays northeast of Jean River.

Canada Geese using the Slave River Delta are of the short-grass prairie population (Bellrose 1976), which consists of approximately 125,000 geese, most of which are Lesser Canada Gesse (Branta canadensis parvipes). They winter in Colorado, Texas, and Nebraska and breed in the Mackenzie Delta and central Arctic (Bellrose 1976). For White-fronted Geese, the migration corridor closest to the Slave River Delta passes through the Mills Lake area, N.W.T. (Bellrose 1976). Bellrose estimates that approximately 51,000-100,000 White-fronted Geese use this corridor. Further to the east, a corridor used by 13,000 to 25,000 White-fronted Geese passes over the Thelon Game Santuary. White-fronted Geese using the Slave River Delta and south shore may be from either of these populations.

Bellrose (1976) estimates that the Slave River Delta and south shore of Great Slave Lake are used by 101,000 to 250,000 Lesser Snow Geese enroute from Peace-Athabasca Delta to the Mackenzie Delta, Anderson River, and Banks Island breeding areas. The low numbers of Snow Geese observed during spring surveys in 1979 suggests that their major migration corridor may not be through the Slave River Delta. However, such a speculation cannot be corraborated from one year's data. Furthermore, 1979 was atypical in having an abnormally late spring. The major flyway for Ross' Geese extends through the east arm of Great Slave Lake. Small numbers of Ross' Geese were seen amongst Snow Geese in Gaudet Bay on 24 May.

The major Whistling Swan migration corridor passes over the Slave River Delta enroute from the Peace-Athabasca Delta to the Mackenzie Delta and Alaska. The population using the corridor is estimated at 30,000 to 60,000 (Bellrose 1976). The Slave River Delta and south shore appear to be slightly less important for swan utilzation than is the Peace-Athabasca Delta. The peak number of swans observed in the Peace-Athabasca Delta in 1971 was 7,619 (Hennan 1971) compared to 5,405 observed on the Slave River Delta and south shore in 1979. Based on Hennan's study, goose utilization of the Peace-Athabasca Delta was much higher than that observed on the Slave River Delta. In comparison to the Mills Lake area (Kemper et al. 1974), however, the Slave River Delta assumes much greater prominance.

In conclusion, the Slave River Delta forms a portion of a larger spring staging area located along the south shore of Great Slave Lake from Fort Resolution to Taltson Bay. The delta provides open water early in the spring for dabbling ducks. The ensuing breakup and spring flood probably helps to provide early open water along the adjacent shoreline and bays of Great Slave Lake. Taltson Bay, Gaudet Bay, and two unnamed bays along the south shore, along with Jackfish Bay, Nagle Bay and the "outer delta" in the Slave River Delta were felt to provide optimum spring staging habitat for geese and swans.

CHAPTER VII

NON-GAME MIGRATORY BIRDS

A. Introduction

Although the main emphasis of this study was to evaluate the delta in terms of waterfowl utilization, efforts were also made to study the non-game migratory birds using the delta. This included raptors, water-oriented birds, passerines and "passerine-like" birds (eg. woodpeckers, kingfishers).

Only by studying all birds occuring in the area can the real importance of the delta be evaluated in the context of migratory birds. The delta, due to its diverse vegetation types, hosts varied groups of bird species, the majority of which are not usually found in the coniferous sections of the boreal forest which dominate the surrounding areas. Large areas of silt flats and sandspits provide suitable habitat for the fall flight of shorebirds.

B. Methods

Several different techiques were used to evaluate non-game migratory bird use of the delta. Nest searches on the sandspits of the "outer delta" were conducted for colonies of Arctic Terns (Sterna paradisea) and California Gulls (Larus californicus). Nests and eggs were counted. Eggs were floated and aged according to Westerkov (1950) in order to predict hatching dates.

Nesting raptors were monitored and nest site data were collected. Nest heights were determined by use of a clinometer on a Silva Compass (Ranger model). All sightings of raptors were mapped to determine areas used by these birds.

Migrating shorebirds were counted during fall migration aerial surveys for waterfowl. Ground censuses were conducted on 20 August, 4, 5, and 6 September in order to determine the species composition of shorebird flocks. Incidental sightings of the other birds were recorded during fall and spring aerial surveys.

A modification of the Breeding Bird Survey (Robbins and Van Velzen 1967) was used to evaluate the delta in terms of breeding use by passerine and "passerine-like" birds (Figure 11). Seven transects, of length varying from 3.2 to 14.5 km were surveyed seventeen times (Table 7). In total, 50.2 km of transects were surveyed with 38 stops. The stops were spaced about 1.25 km apart. At each stop, all species heard and seen during a ten minute interval were recorded. Cassette recordings of a Field Guide to Western Bird Songs (Peterson 1962a) and a Field Guide to Eastern Bird Songs (Peterson 1962b) were used to identify unknown bird songs. Robbins et al. (1966) and Peterson (1961) were also used to identify unknown birds. The direction of each bird in relation to an observation stop was noted to prevent the same individual from being recorded twice. Fifty-five percent of all surveys were conducted in the early morning, 25% in the late evening, and 20% in the mid-afternoon. All surveys were stopped whenever weather conditions became windy or rainy. No attempt was made to estimate the absolute density of the species recorded on the transects.

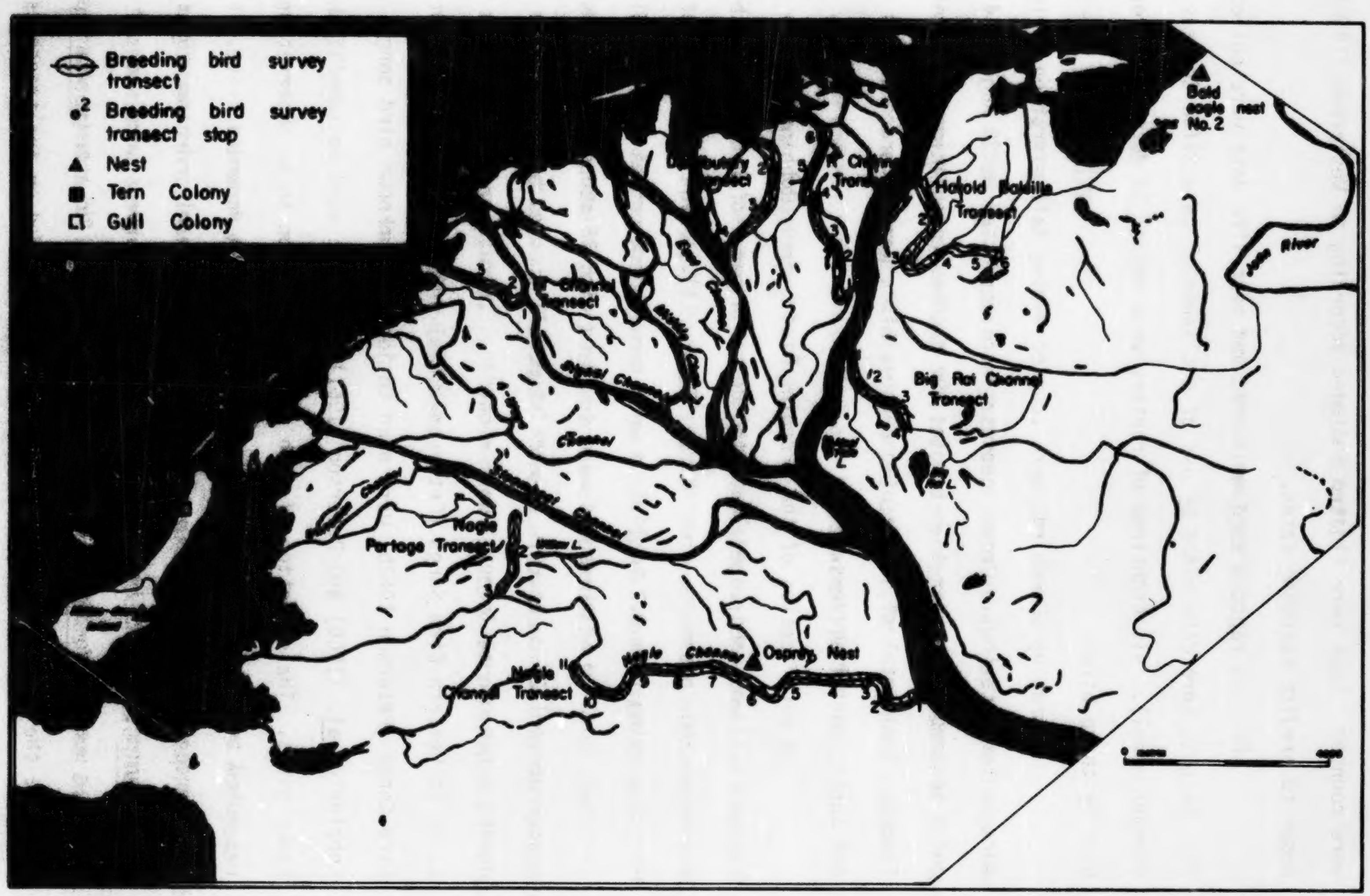

Breeding bird survey transect
2 Breeding bird survey transect stop
▲ Nest
■ Tern Colony
◘ Gull Colony
Bald eagle nest No.2
River
Harold Baldwin Transect
Big Rat Channel Transect
Channel Transect
Nagle Portage Transect
Nagle Channel Transect
Nagle Channel
Osprey Nest
Channel

Figure 11. Locations of Breeding Bird Survey transects and raptor nests, Slave River Delta, N.W.T., 1978.

Table 7. Breeding bird survey transects, Slave River Delta, N.W.T., 1978.

Transect		Transect Lengths (km)	No. of Stops	Replicates
I	(Nagle Channel)	14.5	11	4
II	(Nagle Portage)	3.2	3	3
III	(Big Rat Channel)	5.0	4	2
IV	(Harold Balsillie Channel)	8.0	6	2
V	(M Channel)	5.0	4	2
VI	(R Channel)	8.0	6	2
VII	(East Distributary)	6.5	4	2
TOTALS		50.2	38	17

An index of frequency of occurrence for each species was computed by dividing the number of stops at which a species was observed by the total number of stops on all transects. This index was used to assess the relative abundance of species breeding on the Delta. Vegetation communities at each stop along the transects were noted according to English (1979).

C. Results and Discussion

Observations of various species and groups of non-game birds were recorded as follows:

C.1 Raptors

Sharp-shinned Hawk (Accipiter striatus)

This raptor was sighted once, on 20 June on an abandoned channel northeast of Big Rat Lake. The habitat was of thick deciduous and mixed-wood forest which is generally preferred by this species (Salt and Salt 1976).

Red-tailed Hawk (Buteo jamaicensis)

A pair of Red-tailed Hawks nested near the Jean River, approximately seven km inland from Great Slave Lake. Only one sighting of this species was recorded on the delta, near stop #2 on P Channel Transect on 23 May 1978.

Rough-legged Hawk (Buteo lagopus)

Three individuals which remained on the Delta throughout the summer were observed. Their feeding territories covered areas between 4-ways and Steamboat channels, and included the mouth of Whiteman

Channel, and the area along the southwest shore of Steamboat Channel. Rough-legged Hawks breed in the arctic from Newfoundland to northern Yukon and Alaska (Salt and Salt 1976). Those hawks seen on the delta are believed to have been non-breeding immatures.

Golden Eagle (_Aquila_ _chrysaetos_)

In 1978, one sighting of this raptor was recorded on 23 May in the "outer delta" area. In 1979, two Golden Eagles were sighted on the Slave River Delta on May 14. On spring surveys of the "south shore" eight Golden Eagles (3 immatures, 5 adults) were recorded on 24 May.

Bald Eagle (_Haliaeetus_ _leucocephalus_)

Three Bald Eagle nests were found on the delta (Figure 11). Nest #1, on Round Island near Fort Resolution, was located at the top of a 12 m black spruce tree. On 4 June, two eggs were seen in the nest. Two young were later sighted on 18 July.

Nest #2 was located near the mouth of the Jean River. Two eggs were observed in this nest on 7 June. On 18 July, two young of year were sighted. Between 25 August and 26 September, the young of the year were seen in areas adjacent to the nest site. By 30 September, no eagles were observed in the area.

In spring of 1979, this nest was checked during aerial surveys. On 9 May, one adult Bald Eagle was incubating an unknown number eggs. Both adult birds were seen at the nest site on 14 May.

A third Bald Eagle nest was sighted on Moose-Deer Island on 8 July. The nest was empty. While two adult eagles remained near the nest throughout the summer, they did not successfully breed. No nest or eagles could be found in the spring of 1979.

Ten Bald Eagles (5 immatures, 5 adults) were sighted on 24 May along the south shore of Great Slave Lake.

Osprey (Pandion haliaetus)

One nest having two eggs was sighted on 7 June near Nagle Channel between stops #6 and #7 of Nagle Channel Transect (Figure 12). On 18 July, two young were sighted. Only one fully feathered young was seen in the nest on 25 August. By 2 September, no adult or immature birds were observed in the area.

No evidence of Ospreys was seen on the first spring survey of 1979. By 14 May, however, two Ospreys had returned to the nest site, and incubation of two eggs had begun by 20 May.

Marsh Hawk (Circus cyaneus)

Marsh Hawks were commonly seen on foraging flights over the "outer delta" during the summer. During fall surveys large numbers of this species were sighted migrating through the delta.

Merlin (Falco columbarius)

A total of six sightings of this falcon were recorded. Nagle Channel Transect and Willow Lake were the only two areas in which these birds were observed. Both of these areas have stands of black spruce which could provide suitable nesting habitat.

American Kestrel (Falco sparverius)

This falcon was recorded four times. It was usually seen close to the "outer delta" where large insects, their major food source, were abundant.

Great Horned Owl (*Bubo virginianus*)

A family group of Great Horned Owls, including one adult and two young, was sighted on Nagle Portage Transect on 22, 27 June, and 9 July. Two adults and one downy young bird were sighted on 20 June on an old river channel northeast of Big Rat Lake. On 15 July, one adult and one young Great Horned Owls were seen at stop #2 of R Channel Transect.

Short-eared Owl (*Asio falmmeus*)

This species commonly hunted over the horsetail stands of the "outer delta". The habitat of the delta is suitable for this species as it prefers marshes and wet meadows. However, it is not common in the northern forested regions (Salt and Salt 1976).

C.2 Transients and Visitants

Incidental sightings of spring and fall transient non-game migratory birds were recorded (Table 8). Most of these birds were shorebirds on migration. One sighting was noteworthy. On 1 June 1979 three American Avocet (*Recurvirostra americana*) were sighted close to stop #1 on R Channel Transect. These birds generally breed in the prairie region and are rare in the northern forests. Formerly, however, they bred as far north as the southern Mackenzie region, and were observed at Fort Rae around 1861 (Godfrey 1966). Specimens were taken in the nineteenth century at Fort Rae and Fort Resolution (Godfrey 1966).

A sighting of the rare Caspian Tern (*Hydroprogne caspia*) occurred on 18 July 1978 on a sandspit in the "outer delta". Preble (1908) recorded a Caspian Tern between the Slave River Delta and Stoney

Table 8. Spring and fall migratory non-game birds sighted on the Slave River Delta, N.W.T., 1978.

Spring Transients

Common Loon (*Gavia immer*)

Red-necked Grebe (*Podiceps grisegena*)

Semipalmated Plover (*Charadrius semipalmatus*)
American Golden Plover (*Pluvialis dominica*)
Black-bellied Plover (*P. squatarola*)
Yellowlegs (*Tringa* sp.)
Red Knot (*Calidris canutus*)
Baird's Sandpiper (*C. bairdii*)
Stilt Sandpiper (*Micropalama himantopus*)
Semipalmated Sandpiper (*Calidris pusillus*)
American Avocet (*Recurvirostra americana*)
Parasitic Jaeger (*Stercorarius parasiticus*)

Lapland Longspur (*Calcarius lapponicus*)
Snow Bunting (*Plectrophenax nivalis*)

Fall Transients

Sandhill Crane (*Grus canadensis*)
Semipalmated Plover (*Charadrius semipalmatus*)
American Golden Plover (*Pluvialis dominica*)
Black-bellied Plover (*P. squatarola*)
Yellowlegs (*Tringa* sp.)
Pectoral Sandpiper (*Calidris melanotus*)
Baird's Sandpiper (*C. bairdii*)
Least Sandpiper (*C. minutilla*)
Dowitcher (*Limnodromus* sp.)
Stilt Sandpiper (*Micropalama himantopus*)
Semipalmated Sandpiper (*Calidris pusillus*)
Western Sandpiper (*C. mauri*)
Buff-breasted Sandpiper (*Tryngites subruficollis*)
Hudsonian Godwit (*Limosa haemastica*)
Sanderling (*Caldris alba*)
Northern Phalarope (*Lobipes lobatus*)
Parasitic Jaeger (*Stercorarius parasiticus*)

Horned Lark (*Eremophila alpestris*)
Lapland Longspur (*Calcarius lapponicus*)
Snow Bunting (*Plectrophenax nivalis*)

Island in 1901 and saw several at Fort Resolution in 1908. Soper (1942) saw two individuals near Fort Resolution. Trauger and Bromley (1976) reported three breeding pairs on the West Mirage Islands, Great Slave Lake in 1956. Weller et al. (1969) states that other colonies may exist on Great Slave Lake but they have not been surveyed.

Spring migrants in 1978 were scarce and only Baird's Sandpipers (Calidris bairdii) were frequently sighted. All other spring migrants were sighted once or twice (Table 8).

Large flocks of shorebirds were seen moving through the delta in August. Fall migrating shorebirds were surveyed from 21 August to 30 September (Figure 12). The peak of the shorebird flight occurred on 11 September when 3,101 shorebirds were recorded. The majority of these birds passed through the delta between 6 September and 16 September. These flocks were composed primarily of Pectoral (Calidris melanotus), Semipalmated (C. pusillus), and Baird's Sandpipers. Dowitchers (Limnodromus sp.) and Least Sandpipers (Calidris minatilla) were also seen, but were much less abundant. Yellowlegs (Tringa sp.) and Hudsonian Godwits (Limosa haemastic) were occasionally seen in these flocks. A few sightings were made of the American Golden Plover (Pluvialis dominica), Black-bellied Plover (P. squatorola), Semipalmated Plover (Charadrius semipalmatas), Buff-breasted Sandpiper (Tryagites subruficollis), Stilt Sandpiper (Micropalama himanitopus), Sanderling (Calidris alba), Western Sandpiper (C. mauri), and Northern Phalarope (Lobipes lobatus). The silt flats along the channels provided excellent habitat for these species. The peak of migration occurred in September.

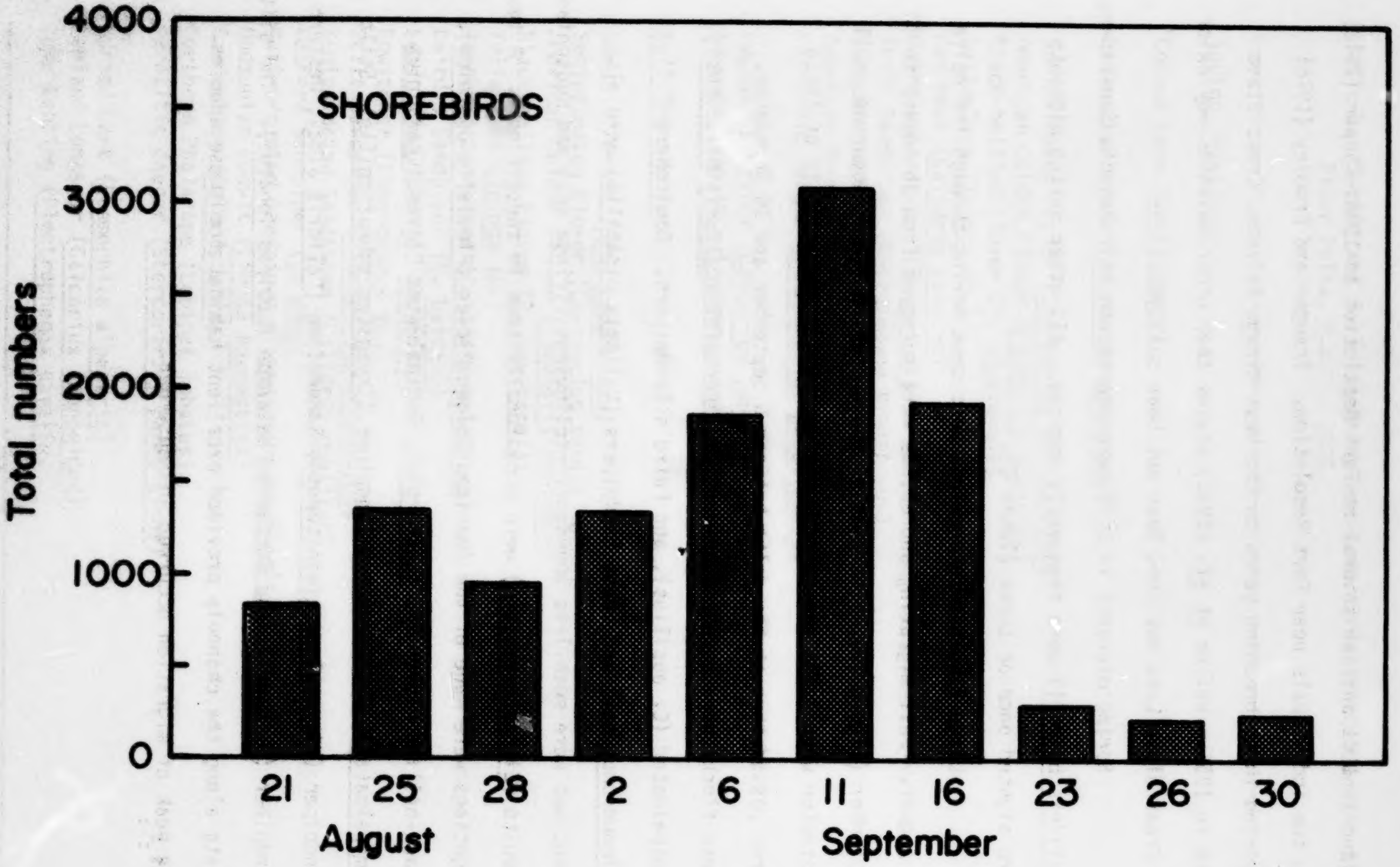


Figure 12. Estimated numbers of shorebirds recorded during fall aerial surveys, Slave River Delta, N.W.T., 1978.

Several flocks of Sandhill Cranes (Grus canadensis) were sighted migrating over the delta in August. There was a resident population of between three and seven birds commonly seen near the airport runway in Fort Resolution. Occasional sightings of a pair of Sandhill Cranes occurred in the Steamboat channel area and near the mouth of Nagle Channel. It was not determined if these birds were breeding.

C.3 Residents

Based on the calculation of frequency of occurrence indices, the most common breeding non-game bird was the Yellow Warbler [(Dendroica petechia) (.354)] (Table 9). Other common species on the delta were the Common Snipe [(Capella gallinago) (.304)], White-throated Sparrow [(Zonotricha albicollis) (.299)], Tree Sparrow [(Spizella arborea) (.268)], Horned Grebe [(Podiceps auritus) (.256)], and Least Flycatcher [(Empidonax minimus) (.256)], Yellow-rumped Warbler [(Dendroica coronata) (.244)], Red-eyed Vireo [(Vireo olivaceous) (.238)], Swainson's Thrush [(Catharus ustulata)], and Common Yellowthroat [(Goethlypis trichas) (.226)], Tennessee Warbler [(Vermivora peregrina) (.213)] and Spotted Sandpiper [(Actitis macularia) (.152)]. Birds with the highest ranking reflect not only their relative abundance, but also reflect the larger amount of specific habitat types surveyed.

Nine different vegetation communities (English 1979) were sampled along the breeding bird survey transects: 39.5% of all transect stops were of Alnus-Salix habitat; Populus habitat was sampled at 21.1% of stops; Salix-Equisetum at 15.8%, successional stages of Picea at 7.9%; and Salix-Alnus at 5.3% of all stops. Four community types, Equisetum, Salix, decandent Populus, and climax Picea were sampled at 2.6% each.

Table 9. Relative abudnance of non-game birds breeding on the Slave River Delta, N.W.T., 1978.

.000 - frequency of occurrence*		Ranking (1) - most common (25) - least common	
Horned Grebe	.256 (5)	American Robin	.073 (14)
Pied-billed Grebe	.018 (23)	Hermit Thrush	.030 (21)
		Swainson's Thrush	.226 (8)
American Bittern	.024 (22)		
		Ruby-crowned Kinglet	.012 (24)
Sora	.018 (23)		
American Coot	.024 (22)	Starling	.037 (26)
Spotted Sandpiper	.152 (10)	Red-eyed Vireo	.232 (7)
Common Snipe	.304 (2)	Warbling Vireo	.043 (19)
Herring Gull	Colonial nester		
California Gull	Colonial nester	Black-and-white Warbler	.043 (19)
Bonaparte's Gull	Colonial nester	Tennessee Warbler	.213 (9)
Arctic Tern	Colonial nester	Yellow Warbler	.354 (1)
Black Tern	Colonial nester	Yellow-rumped Warbler	.244 (6)
		Northern Waterthrush	.049 (18)
Common Nighthawk	.043 (19)	Yellowthroat	.226 (8)
Belted Kingfisher	.018 (23)	Wilson's Warbler	.030 (21)
		American Redstart	.055 (17)
Common Flicker	.079 (13)		
Yellow-bellied Sapsucker	.012 (24)	Red-winged Blackbird	Group nester
Hairy Woodpecker	.030 (21)	Rusty Blackbird	.018 (23)
Downy Woodpecker	.006 (25)	Common Grackle	.061 (16)
Eastern Kingbird	.049 (18)	Western Tanager	.006 (25)
Alder Flycatcher	.061 (16)		
Least Flycatcher	.256 (5)	Rose-breasted Grosbeak	.018 (23)
Western Wood Peewee	.006 (25)		
Tree Swallow	.268 (4)	Savannah Sparrow	.079 (13)
Bank Swallow	.061 (16)	Sharp-tailed Sparrow	.012 (24)
		Dark-eyed Junco	.079 (13)
Gray Jay	.043 (19)	Tree Sparrow	.055 (17)
		White-throated Sparrow	.299 (3)
Common Raven	.128 (11)	Lincoln's Sparrow	.006 (25)
		Swamp Sparrow	.067 (15)
Black-capped Chickadee	.018 (23)	Song Sparrow	.110 (12)
Boreal Chickadee	.066 (16)		

* Frequency of occurrence = $\frac{\text{no. of transect stops sp. present}}{\text{total no. of transect stops}}$

It should be noted that identification of small birds by song is a skill that is developed over many years of experience. Many biases are involved in this type of survey work. On breeding bird surveys some factors that affect the conspicuousness of a species are the physical characteristics of size, colour, and form; the behaviour of the species, including the duration and frequency of its songs and calls, its reproductive patterns, flight characteristics, and wariness; and the environment in which the bird is found (Howell 1951). The transect method may overestimate the density of conspicuous species while underestimating the densities of less detectable species (Davis _et al_. 1975).

Nest searches of colonial Arctic Terns and California Gulls were conducted on 13 June, and 18 July. On 13 June Moose-Deer sandspit and Steamboat sandspit had 12 gull nests and 11 tern nests. Of the 12 gull nests, seven had eggs and five were abandoned. Because of the territorial behaviour of the adult birds (i.e. scolding), active nests were more easily located than abandoned ones. On 18 July, Steamboat sandspit was once again searched and 13 tern nests were found, ten of which were active. However, 14 one week-old terns were found wandering over the sandspit. Three dead chicks were also found. No gull nests were counted on the second survey. Small California Gull and Arctic Tern colonies were also located on the sandspit near the mouth of East Channel. Stelfox and Brewster (1979) indicate that smaller sized gull and tern colonies are characteristic for more northern latitudes.

Groups of nesting Black Terns (_Childonias niger_) were found on Willow Lake on 17 June, Big Rat Lake on 22 June, Noel Yellie Lake on 7 July and Lake #2 on 22 June. These birds were found nesting in horsetail bordering the lakes.

Red-winged Blackbird (Agelaius phoenicus) nesting groups at Willow Lake, Big Rat Lake, and Lake #2 were surveyed on 17, 20, and 22 June respectively. Numbers of territorial males and nests were recorded. Territorial male Red-winged Blackbirds were found in lower densities in the "outer delta" area than on the lakes. This was probably due to the lack of extensive cattail areas in the "outer delta". A total of 70 territorial males were seen on these lakes, which had a combined shoreline length of 11.2 km. The linear density of male Red-winged Blackbirds was 6.52 per km. Sixteen nests were found. Average clutch size was 4.1.

No unique bird populations occurred on the delta. However, the delta does provide habitat for birds such as the Yellow Warbler, American Redstart, Red-eyed Vireo, which are not normally found in the coniferous areas of the boreal forest of this region. Sightings of American Avocets and a Caspian Tern were of noteable importance. A breeding range extension of the Common Yellowthroat was also verified.

CHAPTER VIII

GEOGRAPHICAL SIGNIFICANCE OF THE SLAVE RIVER DELTA

A. Local Significance

In terms of habitat suitable for waterfowl production, the Slave River Delta is superior to the boreal forest which surrounds it. Habitat diversity in the Delta is much greater than that of the surrounding areas and thus provides much more attractive habitat for nesting passerines and waterfowl.

As a staging area for migrating waterfowl, the delta is an important subunit of a larger staging area extending from Fort Resolution along the south shore of Great Slave Lake to Taltson Bay. The "outer delta" in particular is a very important component of this staging area. Due to the presence of large mudflats created by spring sediment deposition followed by low water levels, the delta is also an important migration stop for fall migrating shorebirds.

The residents of Fort Resolution harvest a substantial portion of the delta's game resources. The hunting of migratory waterfowl is significant. Bodden (1979) in his socio-economic study of the natives of Fort Resolution (1975 to 1977) collected data on the importance of wild game in their diet. Waterfowl comprised approximately 39% of the total weight of all wild game consumed by the residents of the village. A total of 3,865 ducks and 616 geese in 1976, and 4,101 ducks and 494 geese in 1977, were taken by six to ten hunters of Fort Resolution (Bodden 1979).

B. Regional Significance

Situated in the southern Mackenzie District and northern Alberta regions, the Slave River Delta is one of the few major breeding areas in the boreal forest. In a regional context, duck utilization during the breeding and migration periods appears to be much higher in the Peace-Athabasca Delta and Mills-Beaver Lakes area. This is not surprising since the Slave River Delta is much smaller and limited in habitat diversity than the latter two areas. It is noteworthy, however, that on a per unit area basis, the Slave River Delta's utilization by migrating geese and swans in possibly higher than the Mills-Beaver Lakes area and certainly comparable to that of the Peace-Athabasca Delta. In any event, these three biologically-rich areas tend to provide "oases" of waterfowl habitat in comparison to the much less productive boreal forest.

C. Continental Significance

The Slave River Delta is located on three of the four major waterfowl flyways of North America. The flyways are Central, Mississippi, and Atlantic (Linduska 1964). Bellrose (1976) estimates that the duck population that passes through the Slave River Delta and the south shore totals between 50,000 and 225,000, the goose population is up to 300,000 and the Whistling Swan population is between 30,000 and 60,000.

The Slave River Delta does not produce a large number of ducks each year. However, as part of the northern boreal forest region, the delta provides available breeding habitat for waterfowl when dry years occur on the prairies. The prairie pothole region is the most important waterfowl production area on the continent. In low water years, when the ponds and sloughs of the prairies dry up, large numbers of adult ducks move northward to the Mackenzie District, N.W.T. where more stable water conditions occur. Some of these displaced ducks breed in the north, however, success is lower (Hanson and McKnight 1964; Smith 1970). The delta, with its rich diverse habitat compared to the surrounding boreal forest, will increase in value at these times.

On a continental basis, the Slave River Delta is of greatest significance as a spring and fall migration stop for Whistling Swans and geese. During migration periods, it probably receives use from the major proportion of the North American Whistling Swan population.

CHAPTER IX

SENSITIVITY TO ENVIRONMENTAL CHANGE

Because of its tremendous hydro-electric potential, future development affecting the Slave River, and hence the Slave River Delta, is a distinct possibility. While the intent, here, is not to look at impact of specific development options, the following discussion attempts to elucidate the relationships between the Delta's water regime characteristics and resultant use by migratory birds. Such information may be useful in future impact studies.

The Slave River Delta exists as a result of fluvial deposition caused by reduced velocity and carrying capacity of sediment of the Slave River as it flows into Great Slave Lake (Reid and Wood 1976). The heavier particles of silt settle out near the mouth while the lighter ones are carried out to settle in the lake bottom. In order for the delta to continue forming, the river must be contributing sediments faster than they are washed away by lake currents and waves. A continuous deposition of sediments causes a lakeward growth of the delta, and the amount of suspended material determines how fast the delta grows (Reid and Wood 1976; Bardach 1964). Because of the tendency of channels to flare into plumes upon entering the lake, mid-channel deposition occurs giving rise to shoals which ultimately form lenticular-shaped islands. This action results in the formation of deltas characterized by branching and occasional rejoining of channels separated by islands (Lauff 1967).

If a reduction in sediment load were to occur upstream of the Delta, the buildup of shoals and bars which are used by geese, swans, and shorebirds for feeding and for protection would be stopped (Stevens 1971). In the long run a decrease in the size of the delta would occur due to erosion by lake waves and currents.

Spring floods flush ice from the river channels and provide open water which is occupied by migrating waterfowl early in the spring (Stevens 1971). Ice jams in some years cause further increases in Delta water levels. The floods allow vegetation in large areas of the delta to be retained at an early successional stage characterized by species such as horsetail (Stevens 1971). These plants are eaten by migrating geese and ducks (Gill et al. 1977). The elimination or reduction of spring floods would delay both the breakup and the resultant early use by waterfowl. If such natural flooding did not occur, colonization by willows and other woody plants in the areas presently restricted to early successional species would take place (Peace-Athabasca Delta Project Group 1972; Stevens 1971). The replacement of early successional species by non-digestible shrubs could reduce the use of these areas by migrating and breeding waterfowl, although for the first two or three years of low water, the feeding areas would be temporarily extended (Peace-Athabasca Delta Project Group 1972). The preferred habitat of waterfowl in the Slave River Delta is that occupied by primary levels of plant succession, which is retained at such early stages by flooding and sediment deposition (Stevens 1971). Perched basins and snyes are important habitat for brood production. They could eventually dry up and become overgrown by vegetation if Slave River floods were reduced. Boreal forest vegetation would extend over a greater area of the delta at the expense of early successional vegetation (Stevens 1971).

With the change to boreal-type ponds, different species of birds would use the area. Bufflehead and Goldeneye sp. would replace American Widgeon and Mallard as common ducks. Habitat for passerines would become less diverse, resulting in the loss of certain species and noticeable changes in species composition. In general, plant and animal diversity of the delta would decrease because of less variety of habitat types. Persistantly high levels on the Delta would have similar affects.

In summary, it is evident that a change in the water regime of the Slave River would have significant effects on the flora, fauna, and physical characteristics of the Slave River Delta. The populations of waterfowl and shorebirds are sensitive to changes that may occur as a result of natural or man-induced alterations in the water regime.

CHAPTER X

SUMMARY AND CONCLUSIONS

1. The objectives of the study were:

> "to compile a list of bird species using the area and their relative status, and to document the area's potential for maintaining rare species."
>
> "to document the use of the study area by migratory birds during the spring staging, breeding, production and fall staging periods in relation to existing habitat conditions, (Mac. Riv. Basin Com. Study Prog. 1978)."

2. The Slave River Delta (61°15'N lat, 113°40'W long) is located 200 km downstream of Fort Smith on the Slave River. The area of the delta is 310 km^2. The Slave River drainage includes large areas of northern British Columbia, Alberta, and Saskatchewan as well as the Slave River Lowlands in the Northwest Territories. Large areas of riparian vegetation occur on the Alluvium land type. The Slave River Delta is located within the sub-arctic climatic zone.

3. The Slave River Delta provides superior breeding habitat for ducks compared to the surrounding boreal forest. The estimated duck breeding population in 1978 was 5,218 pairs of 16.8 pairs per km^2. Common breeding species were, in order of abundance: Lesser Scaup, Mallard, American Widgeon, Bufflehead, and Blue-winged Teal.

4. Brood counts were low relative to breeding pair estimates. During the peak survey, 47 broods (201 ducklings) were recorded. Low brood numbers were attributed to several factors ranging from aircraft

inefficiency to dispersal of breeding pairs to surrounding areas. Most incubation started between 28 May and 24 June 1978. Delayed nesting of dabbling duck species occurred because of the late spring. The main hatch period for all species occurred between 23 June and 17 July 1978. Common brood species were Teal sp., American Wigdeon, Mallard, Bufflehead, Scaup sp., Goldeneye sp., and Canvasback. 1,632 moulters were seen on 11 August.

5. The Slave River Delta is a subunit of an important fall staging area existing along the south shore of Great Slave Lake between Fort Resolution and Taltson Bay. By conservative estimates the south shore of Great Slave Lake supported more than 7,700 swans and 4,400 dark geese on 16 September 1978. In addition, estimated waterfowl numbers of the Delta, itself, reached a peak of 7,634 on that date consisting of 3,957 ducks, 2,169 geese, and 1,508 swans. The Delta and the south shore of Great Slave Lake were felt to be most important as a migration stop for Whistling Swans and to a lesser extent, geese. The Delta's staging value to ducks was considered to be much lower than either the Peace-Athabasca Delta or the Mills-Beaver Lakes.

6. The south shore of Great Slave Lake including the Slave River Delta was also found to be an important spring staging area for swans, geese, and to a lesser extent, ducks. On 25 May 1978, 20,981 waterfowl were counted consisting of 10,257 geese, 5,405 swans and 5,319 ducks. Waterfowl numbers on the Delta, itself, reached a peak of 5,674 on 20 May consisting of 1,569 ducks, 3,715 geese, and 390 swans.

7. The diversity of habitat in the Slave River Delta compared to the surrounding boreal forest makes it important to many species of

raptors, passerines, and shorebirds. Raptors sighted were Sharp-shinned Hawk, Red-tailed Hawk, Rough-legged Hawk, Golden Eagle, Bald Eagle, Osprey, Marsh Hawk, Merlin, American Kestrel, Greated Horned Owl and Short-eared Owl. Three Bald Eagle nests (including one abandoned), one Osprey nest and one Red-tailed Hawk nest were found. Two significant sightings were recorded of American Avocet and Caspian Tern which would be considered rare in the area. Fall staging shorebirds were counted on aerial surveys, the peak occurring on 11 September (3,101). Colonies of Arctic Terns and California Gulls were found on the sandspits of the "outer delta". A modification of the Breeding Bird Survey (Robbins and Van Velsen 1966) was used to evaluate the delta in terms of breeding use by passerines and other birds. In order or abundance, the most common breeders were Yellow Warbler, Common Snipe, White-throated Sparrow, Tree Sparrow, Horned Grebe and Least Flycatcher, Yellow-rumped Warbler, Red-eyed Vireo, Swainson's Thrush and Common Yellowthroat, Tennessee Warbler, and Spotted Sandpiper,.

8. In terms of migratory birds, the Slave River Delta is locally, regionally, and internationally important. Its prime value is as a spring and fall migration stop for swans and geese moving to and from their breeding grounds further north. Migratory birds contribute a large portion of the game harvested by residents of Fort Resolution, N.W.T.

9. Populations of migratory birds would be especially sensitive to any changes that would occur as a result of modifications to the Slave River Delta water regime. For example, a reduction in water

levels and sediment load could affect plant succession and, in turn, utilization by migratory birds. As with other northern deltas, the Slave River Delta is biologically productive because of its naturally fluctuating water regime.

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APPENDIX A

Breeding Pair Data

Table A-1. 23 May reconnaissance flight, waterfowl survey, Slave River Delta, N.W.T., 1978.

Aircraft: Cessna 185 (floats). 450 m at 160 km.

Pilot: Glenn Wakal, Buffalo Airways Ltd., Ft. Smith, N.W.T.

Observers: K. Ambrock, E. Kuyt, K. Bodden

Time: 1330 hrs - 1630 hrs.

Weather: Overcast, ceiling 1200 ft, intermittent rain. Wind northwest 5-10 mph.

General Comments: Great Slave Lake still 95% frozen. Breakup is approximately 10 days later than average. Average breakup date is 11-12 May. All inland sloughs and tribuaries open. Shoreline of Great Slave Lake open approximately 20 years plus large "bay" of open water at Delta.

Results: Survey of "outer delta" only.

Ducks	Geese	Swans	Total
4380	790 (75% Canada geese and 25% White-fronted)	750	5920

Ducks: Most common were Mallard, Lesser Scaup, Ring-necked Duck, and American Widgeon. Other species observed were Pintail, Green-winged Teal (also common), Shoveler, Redhead, Canvasback, Bufflehead, White-winged Scoter, Surf Scoter, and Gadwall.

Other species: Bald Eagle (1 active nest site), Golden Eagle (1), Marsh Hawk, Red-tailed Hawk, Sandhill Crane (3), Coot (common), Black-bellied or Golden Plover, Mew Gulls, California or Ring-billed Gulls (175), Terns, Bonaparte's Gulls, Ravens (common).

Table A-2. Areas censused on breeding pair surveys, Slave River Delta, N.W.T., 1978.

Transects	Length (km)	Area (km)	
		1 June	4 & 7 June
A	54.9	11.0	22.0
B	18.4	3.7	-
C	15.9	3.2	6.4
D	17.6	3.5	-
E	18.0	3.6	7.2
F	16.4	3.3	-
G	17.3	3.4	6.8
H	17.8	3.6	-
I	19.0	3.8	7.6
J	18.8	3.8	-
K	19.1	3.8	7.6
L	19.6	3.9	-
M	15.9	3.2	6.4
N	14.1	2.8	-
O	9.7	1.9	3.8
Ponds	-	-	0.7
Total	-	58.5 km^2	67.8 km^2

Area of Delta (Bodden pers. comm.) = 310 km^2

Percent of area sample (1 June) = 19% (extrapolation factor = 5.26)
(4 & 7 June) = 22% (extrapolation factor = 4.57)

Table A-3. 1 June breeding pair survey, Slave River Delta, N.W.T., 1978.

Aircraft: Cessna 185 (floats)

Pilot: Glenn Wakal, Buffalo Airways Ltd., Ft. Smith, N.W.T.

Observers: R. Quinlan, R. Thompson, (K. Ambrock navigating)

Time: 0730 hrs - 1300 hrs. (Survey time 3 hrs.)

Weather: 1/10 cloud. Wind light and variable.

Results:

Species	Pairs	Lone Male	Lone Female	Lone Duck	Total Pairs
Mallard	51	53	9	25	138
Pintail	1	4	-	-	5
Gadwall	4	-	-	-	4
Widgeon	28	10	5	51	94
Shoveler	2	3	1	-	6
Blue-winged Teal	7	2	-	33	42
Green-winged Teal	4	-	-	4	8
Unid. teal	11	28	-	-	39
Unid. dabbler	-	-	-	61	61
Scaup	90	20	-	35	146
Ring-necked Duck	6	-	-	1	7
Redhead	2	-	-	1	2
Canvasback	4	-	-	2	6
Goldeneye	3	-	-	1	4
Bufflehead	36	19	-	17	72
Ruddy Duck	-	5	-	-	5
Unid. scoter	1	-	-	-	1
Unid. dabbler	-	-	-	104	104
Unid. duck	-	-	-	181	181
Total	-	-	-	-	925

Table A-4. 4 June breeding pair survey, Slave River Delta, N.W.T., 1978.

Aircraft: Cessna 185 (floats)

Pilot: Glenn Wakal, Buffalo Airways Ltd., Ft. Smith, N.W.T.

Observers: R. Quinlan, R. Thompson, (K. Ambrock navigating)

Time: 0810 hrs - 1325 hrs. (Survey time 2 hrs.)

Weather: 9/10 cloud, occasional showers; wind 16 kph from south. Temp. approx. 13°C.

Results:

Species	Pairs	Lone Male	Lone Female	Lone Duck	Total Pairs
Mallard	62	59	11	19	151
Pintail	1	-	-	-	2
Gadwall	1	-	-	8	9
Widgeon	19	12	-	20	51
Shoveler	1	6	-	-	7
Blue-winged Teal	3	1	1	5	10
Unid. teal	3	-	-	15	18
Unid. dabblers	-	-	-	30	30
Scaup	58	40	2	9	109
Ring-necked Duck	1	3	-	-	4
Redhead	-	5	-	-	5
Canvasback	7	16	-	-	24
Goldeneye	3	11	2	2	18
Bufflehead	20	40	5	-	65
Surf Scoter	-	3	-	4	7
Unid. divers	-	-	-	26	26
Unid. ducks	-	-	-	64	64
Total	-	-	-	-	619

Table A-5. 7 June breeding pair survey, Slave River Delta, N.W.T., 1978.

Aircraft: Cessna 185 (floats)

Pilot: Glenn Wakal, Buffalo Airways Ltd., Ft. Smith, N.W.T.

Observers: R. Quinlan, R. Thompson, (K. Ambrock navigating)

Time: 0730 hrs - 1130 hrs. (Survey time 2 hrs.)

Weather: 5/10 cloud, wind 10 mph from east.

Results:

Species	Pairs	Lone Male	Lone Female	Lone Duck	Total Pairs
Mallard	30	75	16	6	126
Pintail	4	9		4	17
Gadwall		2			2
Widgeon	4	12	1	15	32
Shoveler	5	15		2	22
Blue-winged Teal	3	2		13	18
Green-winged Teal				1	1
Unid. teal	2			6	8
Unid. dabbler				62	62
Scaup	51	34	8	19	112
Ring-necked Duck	1	6			7
Redhead	1	2			3
Canvasback	6	1		6	13
Goldeneye	2	8	1	1	12
Bufflehead	18	40	8	8	74
Ruddy Duck		11			11
White-winged Scoter		1			1
Unid. diver				47	47
Unid. ducks				131	131
TOTAL					699

APPENDIX B

Brood Production Data

Table B-1. 18 July brood survey, Slave River Delta, N.W.T., 1978.

Aircraft: Bell 206B helicopter
Time: 0745 hrs - 1025 hrs.

Weather: Temp 7°C, wind N 15 kph, cloud 9/10 cover, precip. 0, good visibility

Age Class	Dabblers					Divers						Unid. Ducks	TOTAL
	Mal	Widg	Shov	Teal	Unid.	Scaup	Canv	CG	Puff	Ruddy	Unid.		
Ia									1(4)*				1(4)
Ib	3(14)	1(6)	1(6)	7(32)	1(4)	2(21)		1(1)	3(10)		1(5)	1(2)	21(101)
Ic	1(2)	3(14)		2(17)	2(9)	1(3)	1(2)		1(7)				11(54)
IIa		3(8)			2(6)								5(14)
IIb		2(4)			2(4)								4(8)
IIc	1(2)												1(2)
III													
Unknown class				1(1)	2(12)	1(5)							4(18)
Moulters	93	77	1	24	82	59		11	18	2	119	102	588
TOTAL	5(18)	9(32)	1(6)	10(50)	9(35)	4(29)	1(2)	1(1)	5(21)		1(5)	1(2)	47(201)

* 1 = total number of broods per subclass per species.
(4) = total number of ducklings per subclass per species.

Table B-2. 27 July brood survey, Slave River Delta, N.W.T., 1978.

Aircraft: Cessna 185 fixed-wing
Time: 0722 hrs - 0945 hrs.

Weather: Temp 14°C, wind E 12 kph, cloud 1/10 cover, precip. 0, good visibility

Age Class	Dabblers					Divers						Unid. Ducks	TOTAL
	Mal	Widg	Shov	Teal	Unid.	Scaup	Canv	CE	Puff	Ruddy	Unid.		
Ia													
Ib					1(6)*								1(6)
Ic	1(1)	1(5)		1(6)	1(4)	1(3)					3(8)		8(27)
IIa	1(4)	1(5)		1(1)	4(16)							1(3)	8(29)
IIb					1(1)		1(4)		1(2)		1(7)		4(14)
IIc													
III	1(10)				1(4)								2(4)
Unknown class													
Moulters	71	7	30	1	81	36	5	2	7		82	147	469
TOTAL	3(15)	2(10)		2(7)	8(31)	1(3)	1(4)		1(2)		4(15)	1(3)	23(90)

* 1 = total number of broods sighted per subclass per species.
(6) = total number of ducklings per subclass per species.

Table C-3. 11 August brood survey, Slave River Delta, N.W.T., 1978.

Aircraft: Cessna 185 fixed-wing
Time: 0800 hrs - 1000 hrs.

Weather: Temp 12°C, wind E 12 kph, cloud 2/10 cover, precip. 0, good visibility

Age Class	Dabblers					Divers						Unid. Ducks	TOTAL
	Mal	Widg	Shov	Teal	Unid.	Scaup	Canv	CE	Buff	Ruddy	Unid.		
1a													
1b					1(6)*								1(6)
1c		1(5)		1(4)								1(1)	3(10)
11a		1(4)						1(2)					2(6)
11b		1(1)											1(1)
11c					2(5)	2(9)							4(14)
111					1(4)								1(4)
Unknown class													
Moulters	187	3		287	176	90		1		6	15	867	1632
TOTAL		3(10)		1(4)	4(15)	2(9)		1(2)				1(1)	12(41)

* 1 = total number of broods per subclass per species.
(6) = total number of ducklings per subclass per species.

APPENDIX C

Spring Migration Data

Table C-1. Spring migration surveys - species compilation, Slave River Delta, N.W.T., 1979.

Species	14 May	17 May	20 May	22 May	25 May	30 May	2 June
Arctic Loon			1				
Unid. loon						2	
Red-necked Grebe		2	4		1		
Horned Grebe			4				
Whistling Swan	174	386	390	752	837	1339	548
Canada Goose		33	10				
White-fronted Goose		900		3			
"Dark" Goose	137	673	3255	2152	518	75	17
"White" Goose	155	1	450	104	75		
Mallard	330	169	70	40	45	40	36
Pintail	25	1	8	1	5	4	
Blue-winged Teal		1					
Green-winged Teal	8	1					
Unid. teal	5		21	1		4	
American Widgeon	568	63	94	12	38	17	19
Shoveler		1	16		2	2	5
Ring-necked Duck		13	3			2	3
Canvasback	19	49	5	8	7	26	11
Unid. scaup	102	363	432	489	1051	1313	160
Unid. goldeneye	12	14	44	43	20	10	12
Bufflehead	39	36	34	14	12	15	10
Oldsquaw	1						
White-winged Scoter				4	2		
Surf Scoter			60	57	2	73	2
Unid. scoter				49	50	12	1
Ruddy Duck				1			1
Unid. merganser							
Rough-legged Hawk	1	1				1	
Golden Eagle	1						
Bald Eagle	5	3	1	1		1	
Unid. eagle	1						
Marsh Hawk	1	2	7	3	19	2	
Unid. buteo	1	2	1				
Kestrel		1					
Sandhill Crane		1		6		15	
American Coot					1		
"Shorebirds"	332	51	1	30	4	176	761
"White-headed" Gull	62	83	124	49	227	36	49
Bonaparte's Gull	3				1		1
Unid. tern				4		25	28
Black Tern						1	2
Great Horned Owl	1			1			
Short-eared Owl	2		3		1		
Raven	29	33	6	11	6	8	1

APPENDIX D

Breeding Birds

Appendix D-1. Species with known breeding distribution (Godfrey 1966) in the study area.

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* - found breeding on study site in summer 1978

Common Loon	Gavia immer	
Arctic Loon	G. arctica	
Red-throated Loon	G. stellata	
Red-necked Grebe	Podiceps grisegena	
Horned Grebe	P. auritus	*
Pied-billed Grebe	Podilymbas podiceps	*
American Bittern	Botaurus lentiginosus	*
Canada Goose	Branta canadensis	
Mallard	Anas platyrhynchos	*
Pintail	A. acuta	
Green-winged Teal	A. crecca	*
Blue-winged Teal	A. discors	*
American Widgeon	A. americana	*
Northern Shoveller	A. clypeata	*
Redhead	Aythya americana	
Ring-necked Duck	A. collaris	*
Canvasback	A. valisineria	*
Greater Scaup	A. marila	
Lesser Scaup	A. affinis	*
Common Goldeneye	Bucephala clangula	*
Bufflehead	B. albeola	*
White-winged Scoter	Melanitta deglandi	
Surf Scoter	M. perspicillata	
Ruddy Duck	Oxyura jamaicensis	*
Common Merganser	Mergus merganser	
Red-breasted Merganser	M. serrator	
Goshawk	Accipiter gentilis	
Sharp-shinned Hawk	A. striatus	*
Red-tailed Hawk	Butea jamaicensis	*
Bald Eagle	Haliaeetus leucocephalus	*
Marsh Hawk	Circus cyaneus	*
Osprey	Pandion haliaetus	*
Merlin	Falco columbarius	*
American Kestrel	Falco sparverius	*
Spruce Grouse	Canachites canadensis	
Ruffed Grouse	Bonasa umbellus	
Sharp-tailed Grouse	Pedioecetes phasianellus	
Sora	Porzana carolina	*
Yellow Rail	Coturnicops noveboracensis	
American Coot	Fulica americana	*

Appendix D-1 continued.

Semipalmated Plover	*Charadrius semipalmatus*	
Killdeer	*C. vociferus*	
Common Snipe	*Capella gallinago*	*
Spotted Sandpiper	*Actitis macularia*	*
Solitary Sandpiper	*Tringa solitaria*	
Lesser Yellowlegs	*T. falvipes*	
Short-billed Dowitcher	*Limnodromus griseus*	
Herring Gull	*Larus argentatus*	*
California Gull	*L. californicas*	
Mew Gull	*L. canus*	
Bonaparte's Gull	*L. philadelphia*	*
Common Tern	*Sterna hirundo*	
Arctic Tern	*S. paradisaea*	*
Black Tern	*Childonias niger*	*
Great Honed Owl	*Bubo virginianus*	*
Hawk Owl	*Surnia ulula*	
Great Gray Owl	*Strix nebulosa*	
Long-eared Owl	*Asio otus*	
Short-eared Owl	*A. flammeus*	*
Boreal Owl	*Aegolius funereus*	
Common Nighthawk	*Chordeiles minor*	*
Belted Kingfisher	*Megaceryle alcyon*	*
Common Flicker	*Colaptes auratus*	*
Pileated Woodpecker	*Dryocopus pileatus*	
Yellow-bellied Sapsucker	*Sphyrapicus varius*	*
Hairy Woodpecker	*Picoides villosus*	*
Downy Woodpecker	*P. pubescens*	*
Black-backed Three-toed Woodpecker	*P. arcticus*	
Northern Three-toed Woodpecker	*P. tridactylus*	
Eastern Kingbird	*Tyrannus tyrannus*	*
Eastern Phoebe	*Sayornis phoebe*	
Say's Phoebe	*S. saya*	
Yellow-bellied Flycatcher	*Empidonax flaviventris*	
Traill's Flycatcher	*E. traillii*	*
Alder Flycatcher	*E. alnorum*	*
Least Flycatcher	*E. minimus*	*
Western Wood Peewee	*Cantopus sordidulus*	
Olive-sided Flycatcher	*Nuttallornis borealis*	
Horned Lark	*Eremophila alpestris*	
Tree Swallow	*Tridoprocne bicolor*	*
Bank Swallow	*Riparia riparia*	*

Appendix D-1 continued.

Barn Swallow	Hirundo rustica	*
Cliff Swallow	Petrochelidor pyrrhonota	
Gray Jay	Perisoreus canadensis	*
Common Raven	Corvus corax	*
Common Crow	C. brachyrhynchos	
Black-capped Chickadee	Parus atricapillus	*
Boreal Chickadee	P. hudsonicus	*
Red-breasted Nuthatch	Sitta canadensis	
American Robin	Turdus migratorius	*
Hermit Thrush	Catharus guttata	*
Swainson's Thrush	C. ustulata	*
Gray-cheeked Thrush	C. minima	
Ruby-crowned Kinglet	Regulus calendula	*
Bohemian Waxwing	Bombycilla garrulus	
Northern Shrike	Lanius excubitor	
Common Starling	Sturnus vulgaris	*
Solitary Vireo	Vireo solitarius	
Red-eyed Vireo	V. olivaceous	*
Warbling Vireo	V. gilvus	*
Black-and-white Warbler	Mniotilta varia	*
Tennessee Warbler	Vermivora peregrina	*
Orange-crowned Warbler	V. celata	
Yellow Warbler	Dendroica petechia	*
Magnolia Warbler	D. magnolia	
Cape May Warbler	D. tigrina	
Yellow-rumped Warbler	D. coronata	*
Blackpoll Warbler	D. striata	
Palm Warbler	D. palmarum	
Ovenbird	Seiurus aurocapillus	
Northern Waterthrush	S. noveboracensis	*
Wilson's Warbler	Wilsonia pusilla	*
American Redstart	Setophaga ruticilla	*
Red-winged Blackbird	Agelaius phoenicus	*
Rusty Blackbird	Euphagus carolinus	*
Common Grackle	Quiscalus quiscula	*
Brown-headed Cowbird	Molothrus ater	
Western Tanager	Piranga ludoviciana	*
Rose-breasted Grosbeak	Pheuticus ludovicianus	*
Purple Finch	Carpodacus purpureus	
Pine Grosbeak	Pinicola enucleator	
Common Redpoll	Carduelis flammea	
Pine Siskin	C. Pinus	
Red Crossbill	Loxia curvirostra	
White-winged Crossbill	L. leucoptera	
Savannah Sparrow	Passerculus sandwichensis	*
Le Conte's Sparrow	Ammospiza LeConteii	
Sharp-tailed Sparrow	A. caudacuta	*
Vesper Sparrow	Pooecetes gramineus	

Appendix D-1 continued.

Dark-eyed Junco	Junco hyemalis	*
Tree Sparrow	Spizella arborea	*
Chipping Sparrow	S. passerina	
Clay-colored Sparrow	S. pallida	
White-crowned Sparrow	Zonotricha leucophrys	
White-throated Sparrow	Z. albicollis	*
Fox Sparrow	Passerella iliaca	
Lincoln's Sparrow	Melospize lincolnii	*
Swamp Sparrow	M. georgiana	*
Song Sparrow	M. melodia	*
Common Yellowthroat	Geothlypis trichas - not delineated in Godfrey (1966)	*

DEPARTMENT OF INDIAN AFFAIRS
AND NORTHERN DEVELOPMENT

Northern Affairs Program, Water Resources Division
Yellowknife

E

Productivity and Habitat Selection of Muscrats in the Slave River Delta

Prepared by

Frank Geddes,
Consultant.

Edmonton, Alberta

EXECUTIVE SUMMARY

The Slave River Delta, located at 61° 13' N, 113° 38' W, is one of three major wetlands of the Mackenzie River system. As in other northern deltas, the muskrat has long been the most important economic species; more than 75,000 pelts per year have sometimes been traded at Fort Resolution. In 1978, a study was initiated, as part of the Mackenzie River Basin Study Program, to gather baseline data on muskrat habitat selection and productivity in this wetland.

Aerial surveys were flown each spring, fall, and early winter to record the distribution and abundance of muskrat houses and pushups. Complementary ground surveys were used to determine the accuracy of aerial observations, the ratio of active to inactive lodges, habitat characteristics, and the presence of bank burrows. To help understand the importance of the hydrologic regime to muskrat ecology, water levels and snow and ice thicknesses were monitored. Food habits and indications of predation were qualitatively assessed from general observations.

Habitat suitable for the construction of muskrat houses existed principally in the bays along the outer delta and in the few inter-levee lakes or perched basins. These standing water bodies supported abundant growth of aquatic plants which were used by muskrats for both food and lodge construction. Large pieces of driftwood, dispersed through the shallow water of emergent stands by spring floods or wave action, provided elevated sites for summer house construction.

Houses were especially abundant in these areas during the 1975-76 peak of the muskrat population and up until the winter of 1977-78, when the population declined rapidly. Circular openings 3 to 4 m in diameter, and trails radiating from these openings, remained as remnants of past activity.

Few active houses were found in these areas after the population decline. During aerial surveys in the fall of 1978, 1979, and 1980, only 21, 18, and 26 houses were recorded, respectively, on the delta. Furthermore, by February 1979 all houses located were determined to be inactive, while in March 1980 only 2 of 15 houses (13.3%) were potentially in use. Severe cold, direct exposure to strong northwest winds off Great Slave Lake, and a shallow snow cover, combined to freeze the water around muskrat houses to depths greater than 1 m.

Standing water bodies on the delta are therefore inferior winter habitat during years of low water or severe cold. They are important only during favorable winters when they provide the necessary habitat to support temporarily high populations of muskrats.

Because suitable long-term habitat for building muskrat houses is restricted in the Slave Delta, bank burrows were more typically used. Unlike the Mackenzie Delta, however, the lakes and perched basins of the Slave Delta have gently sloping bottoms which preclude the construction of bank burrows. Optimum habitat for bank denning was principally found along active distributaries, particularly those with moderately sloping levees and a littoral band of emergent vegetation. Ice thicknesses along these banks rarely exceeded 0.5 m, providing easy access to underwater portions of emergent vegetation. An air space was often created between the ice and water by declining channel levels in winter; this enhanced the suitability of these distributaries as winter habitat by allowing the muskrats to forage along channel margins from mid to late winter.

Although emergent vegetation was accessible during the winter in most of the smaller channels, its availability was often restricted by freezing in the exposed bays and small lakes. Submerged aquatics, abundant only in the still water of lakes and bays, were likewise restricted in availability. Thus, during severe winters, emergent vegetation along active channels constituted the major winter food of muskrats.

Examination of carcasses, collected each fall from hunters and trappers, revealed reproductive potential of muskrats on the Slave Delta to be high. Mean yearly production per female (determined from placental scar counts) was 17.8, 16.4, and 18.3 for 1978, 1979, and 1980, respectively. All direct evidence suggested that most adult females probably produced two litters per year; thus, mean litter size for the three years was 8.7, based on placental scar counts.

The possibility of a third litter, especially during longer than average summers, cannot be discounted. In 1980 (a long season), mean production per female was greater than in the two preceding years. As well, placental scar counts for the three years, when divided by only two litters per year, provided a higher estimate of litter size than did field examination of pregnant females (8.7 to 7.9,respectively).

The percentage of subadults in fall carcass collections varied from 74.1% in 1978 to 80.1% in 1980, with a three year mean of 77.1%. Juvenile/adult female ratios from the three carcass collections were 6.6:1, 6.7:1, and 8.8:1,respectively.

Comparison of reproductive rates with fall age ratios showed summer survival rates of juveniles to be low. However, this may be, in part, because fall age ratios were balanced in favor of adults (which were more vulnerable to shooting).

The greatest natural mortality factor affecting muskrats in the summer was likely predation by mink and raptorial birds, although further research is needed to substantiate this. Winter mortality was attributed chiefly to freezing of water surrounding muskrat houses, thereby restricting food availability. During peaks in the muskrat population, other factors such as epizootics and fighting are probably important in culling the population.

Because of its hydrologic regime, the Slave River Delta is highly productive of muskrats, compared with surrounding areas. It is locally important to the residents of Fort Resolution who use the muskrat to provide a substantial portion of their income and country food supply. Regionally, it is the most productive muskrat area between the Mackenzie and Peace-Athabasca Deltas. In the Northwest Territories, for example, Fort Resolution is second only to Inuvik in producing the greatest sustainable yield of muskrats, most of which are harvested on the Slave River Delta.

The productivity of the Slave River Delta is, in large part, due to the periodic flooding and sediment load of the Slave River. The river regime creates valuable muskrat habitat in two ways: (1) physically, many waterways, cleavage bars, and interlevee depressions are formed when the river drops its sediment load at the lake, and (2) successionally, periodic flooding maintains the delta in a youthful state with highly productive emergent and aquatic plants. Any long-term perturbations to the hydrologic regime which would promote succession to climax vegetation would lessen the capability of the delta to support muskrat populations. Production of food species would be reduced to a level typical of neighboring sloughs and ponds.

The importance of the hydrologic regime to the physical characteristics of muskrat habitat is variable and primarily affects winter habitat. During favorable years, muskrats build typical winter houses as in the Peace-Athabasca Delta, yet when water levels are low, they are restricted to bank burrows as in the Mackenzie Delta. Superior habitat is that which enables muskrats to successfully overwinter in houses. Reductions in winter water levels prevents the exploitation of such areas, and therefore limits the productivity of the delta.

Years of low water levels make muskrat populations on the Slave Delta especially vulnerable to changes in the hydrologic regime and winter weather. If the natural river regime were upset such that hang-ice habitat along channels were eliminated, or flow rates were increased, over wintering in bank burrows might be all but impossible. This would have dramatic effects on the muskrat population during low periods in the population cycle and during harsh winters.

Valuable information about the habitat selection and productivity of muskrats on the Slave Delta was obtained in this study. However, the yearly variation in suitability of winter habitat, and unanswered questions regarding the importance and vulnerability of bank burrow habitat to changing hydrologic or population characteristics, necessitates further research. Monitoring of habitat characteristics and muskrat populations should continue for at least the duration of two population cycles.

Hunting and trapping on the Slave River Delta have always been, and still are, important to the indigenous people of Fort Resolution. Indications are that these activities cannot easily be replaced by alternate forms of employment; the value of fur trapping to these people is much more than a matter of economics. A thorough understanding of the ecology of muskrats on the Slave Delta, and its relationships to the hydrologic regime, is important to maintain the social, economic, and cultural value of this resource.

LETTER OF TRANSMITTAL

October 27, 1981

Mr. Frank Geddes
9618 - 73 Avenue
EDMONTON, Alberta
T6E 1B2

Mr. Bruce Stephenson, Supervisor
Management Studies
N.W.T. Wildlife Service
Department of Renewable Resources
Government of the N.W.T.
YELLOWKNIFE, N.W.T.
X1A 2L9

Dear Mr. Stephenson:

Enclosed is a final report entitled "Productivity and Habitat Selection of Muskrats in the Slave River Delta". This report summarizes the salient findings of a three-year study of muskrats in the Slave Delta, conducted from 1978 to 1980. This study was funded through the Mackenzie River Basin Study Program and administered by the N.W.T. Wildlife Service through Contract No. CT-78-1-471.

The purpose of the study was to gather baseline data on the distribution, abundance, and population dynamics of muskrats in this wetland, and to examine the role of the hydrologic regime in the maintenance of muskrat populations. It is concluded that muskrat abundance and distribution, overwinter survival, and selection of dwelling habitats varies according to changes in water levels. It is shown that the Slave River Delta is a unique wetland, having characteristics which are similar to each of the other major deltas in the Mackenzie River drainage, yet showing great variability in habitat suitability in response to changing hydrologic conditions. Muskrat productivity on the Slave River Delta is comparable to other highly productive northern wetlands.

Logistical problems and the low status of the muskrat population at the time of the study hampered the collection of quantitative information on most aspects of muskrat ecology. Nonetheless, considerable insight was gained into the special and variable nature of muskrat habitat on this delta. To fully assess the importance of the hydrologic regime, I strongly recommend that monitoring of water levels and ice thicknesses, activity of muskrat houses, and reproductive estimators be conducted for at least the duration of two population cycles.

I trust that you will find this report to be useful to understanding the importance of the hydrologic regime of the Slave River Delta to the valuable muskrat resource. I wish to thank you for the opportunity to participate in this project and am especially grateful for your helpful guidance.

Sincerely yours,

Frank E Geddes

Frank E. Geddes
Wildlife Biologist

FEG/cbc
Encl.

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Chapter I

INTRODUCTION

The Slave River Delta is one of three larger wetlands within the Mackenzie River drainage basin. The relative dwarfness of this delta (it covers approximately 200 km^2) when compared to the Mackenzie Delta to the northwest and the Peace-Athabasca Delta to the southeast, is in part, responsible for the fact that it has been the least studied of the major wetlands in the Mackenzie River system. Although the delta was once an important link in a major northern transportation route, its primary importance today is that it provides feeding, staging, and breeding habitats for large numbers of waterfowl, muskrat, and other wildlife species.

The muskrat *(Ondatra zibethicus)* is the animal resource of the delta which is of greatest economic importance to the people of Fort Resolution (located approximately 10 km to the southwest), who depend upon it to provide a substantial portion of their income and country food supply. For example, during the recent high muskrat population of 1975-76, muskrat harvests accounted for approximately $89,000.00 in fur sales and $55,000.00 in imputed food value. These combined figures represent over 65% of all income and food value obtained from the wildlife resources of the delta in that period (Bodden 1981).

Little information is available about the ecology of muskrats on the Slave Delta. A preliminary study by the Canadian Wildlife Service (Law 1950) found muskrats to be occupying only bank burrows along active channels. (This is unlike habitat selection in the Peace-Athabasca or Mackenzie Deltas where muskrats occupy houses or bank burrows in lakes.) As well, it was concluded that "water levels play a prominent role in muskrat ecology" and that "principal possibilities for management on the Slave Delta revolve around winter mortality" but that more essential information was still needed on the ecology of these muskrats.

The current study was initiated in the spring of 1978 to gather baseline data, particularly on the distribution, abundance, and population dynamics of muskrats on the Slave Delta, and to examine the effects of changes in the hydrologic regime on this resource and its habitat.

An important early finding of this study was that the original census techniques were not suitable for obtaining adequate information on the distribution and abundance of muskrats on the Slave River Delta, primarily because of the paucity of muskrat houses. Additional procedures - such as a marking and live-trapping program - were initiated later in the study, but were unable to provide sufficient estimates of relative abundance between habitats. This was because the muskrat population had recently declined dramatically and was at the low point of its cycle.

The results of this study should, therefore, be taken as preliminary. While considerable insight was gained regarding the unique and varying characteristics of muskrat habitat on the Slave Delta, long-term studies are required to fulfill the objectives of this project. Recommendations for further research to sustain the muskrat productivity of this wetland (and therefore the socio-economic value to local residents), are included in the final sections of the report.

Chapter II

THE SLAVE RIVER DELTA

A. Geographic Setting

The Slave River Delta is located at 61° 13' N, 113° 38' W, where the Slave River discharges into Great Slave Lake, Northwest Territories (Figure 1). The center of the delta is 10 km NNE of Fort Resolution, N.W.T., while the nearest active distributary (Nagle Channel) is only 3.5 km from the settlement. The boundaries of the delta as described by English (1979) are suitable for this study; Nagle Channel defines the southern border, a line from the center of the Slave River at Nagle Channel (61° 15' N, 113° 30' W) to an island in the bay at the mouth of the Jean River (61° 21' N, 113° 33' W) represents the northeastern border, and the shoreline of Great Slave Lake delimits the northwestern border. The total area of the delta is 210 km^2, of which 78 km^2 is made up of active channels (English 1979).

B. Climate

Fort Resolution (the nearest weather station) experiences long, cold winters and short, cool summers typical of a continental subarctic climate. Over a 30-year period (1941-1970) records show a mean annual temperature of -4.1° C; the summer mean maximum (July) is 15.7° C, the winter mean minimum (January) is -26.3° C (Alberta Environment 1978).

The influence of Great Slave Lake in extending the frost free period has been noted by Day (1972) and English (1979). As this large expanse of open water helps ameliorate spring and fall minimums, Fort Resolution has a much longer frost free period (103 days) than does Fort Smith (59 days),

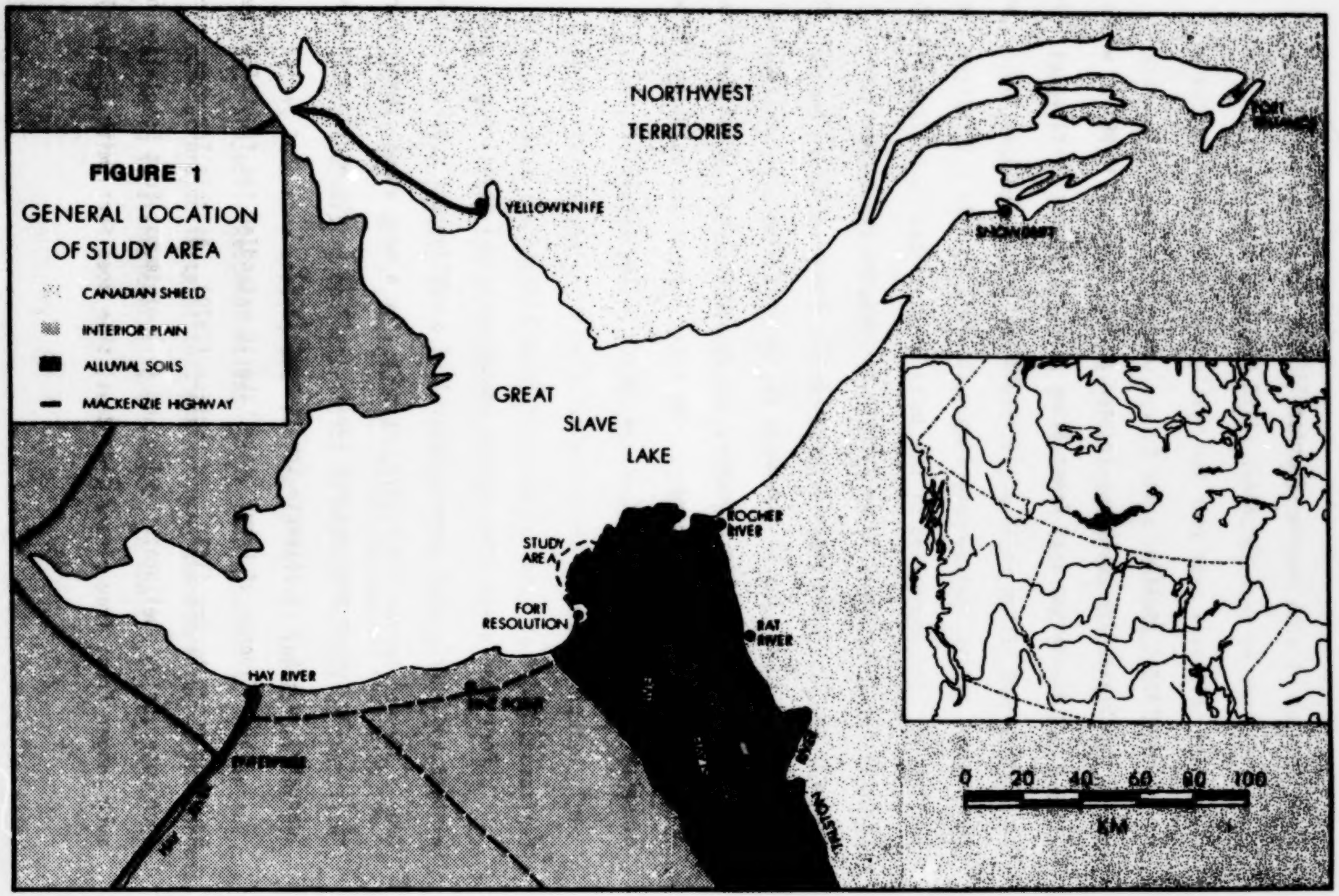

FIGURE 1
GENERAL LOCATION
OF STUDY AREA

CANADIAN SHIELD
INTERIOR PLAIN
ALLUVIAL SOILS
MACKENZIE HIGHWAY
NORTHWEST
TERRITORIES
YELLOWKNIFE
SNOWDRIFT
GREAT
SLAVE
LAKE
ROCHER
RIVER
STUDY
AREA
FORT
RESOLUTION
RAT
RIVER
HAY RIVER
0 20 40 60 80 100
KM

located 165 km southeast (Day 1972). However, the dual effect of the lake in lowering summer maximums causes Fort Resolution to have a much shorter, cooler growing season than Fort Smith (130 to 141 respectively; Day 1972).

Precipitation averages 29.56 cm per year, about half of this falling as snow (15.39 cm water-equivalent units) between mid-October and mid-May (Alberta Environment 1978). Strong northwest winds in the winter re-distribute the snow along the lakeshore such that much of the outer delta is left either snow-free or with only a thin layer of hard-packed snow.

Breakup on the delta is usually around mid-May while channels freeze in late October. The open water season is approximately five months but may vary a couple of weeks either way.

C. Soils and Permafrost

The Slave River Lowland extends from Fort Smith to Great Slave Lake and is flanked on the east and west by the Taltson and Little Buffalo rivers, respectively. Believed to have originally been the southern arm of a much larger lake, this valley was gradually filled with lacustrine and alluvial deposits after the recession of Glacial Lake McConnell, ca. 8500 BP (Cameron 1922). Today, the Slave River Delta is the primary site of active deposition.

Recent alluvium covers the majority of the delta and portions of the shoreline along Great Slave Lake to Gaudet Bay. These Cumulic Regosols are mostly calcareous, dark grayish brown, fine sandy loams with a very shallow litter layer. They are not underlain by permafrost.

Jerome and Taltson soils are associated with less active or abandoned channels which are no longer frequently flooded. They are principally found near Little Jean River, an old distributary linking the main Slave River to

Jean River. Both these soil series have developed on organic-rich, calcareous alluvium. The Jerome soils are Cryic Cumulic Regosols, which overlie permafrost on terraces and ridges. These ridges are separated by the poorly drained Taltson Rego Gleysols which contain no permafrost (Day 1972).

The Iche soil series also occurs in older parts of the delta, such as near Nagle Channel. These Cryic Cumulic Regosols are moderately well drained and underlain by permafrost, although not as well drained or as rich in organic matter as are the Jerome soils (Day 1972).

D. Vegetation

The Slave River Delta is part of the Upper Mackenzie Boreal Forest Region (Rowe 1972). However, due to the hydrologic regime, most of the delta never matures to climax vegetation typical of the neighboring forest.

Plant assemblages on the Slave River Delta have been well described by English (1979). Willows (*Salix* spp.) dominate the terrestrial vegetation of the outer delta and cleavage bars where flooding occurs annually. Generally, succession proceeds from *Salix* to *Alnus* to *Populus*, decadent *Populus balsamifera* being the edaphic climax species in the mid-delta regions. Periodic inundation of most of the delta prevents the germination of *Picea* seedlings such that white spruce (*Picea glauca*) stands are restricted to few, isolated areas, such as on the Jerome and Iche soils (English 1979). Major components of the understory include red osier dogwood (*Cornus stolonifera*), rose (*Rosa acicularis*), high bush cranberry (*Viburnum edule*), fireweed (*Epilobium angustifolium*), and water horsetail or "goosegrass" (*Equisetum* spp.) (English 1979).

Aquatic vegetation is well developed in water bodies which are sheltered from wind or wave action and frequent flooding. In these lakes and interlevee depressions, the most abundant littoral vegetation species are goosegrass (*Equisetum fluviatile*), sedges (*Carex* spp.), and cattail (*Typha latifolia*). Submerged and floating plants include: pondweeds (*Potamogeton* spp.), milfoil (*Myriophyllum exalbescens*), yellow pond lily (*Nuphar variegatum*), mare's tail (*Hippuris vulgaris*), arrowhead (*Sagittaria cuneata*), bladderwort (*Utricularia* spp.), *Ranunculus* sp., and duckweeds (*Lemna* spp.).

Submerged and floating plants are less abundant in lakes which annually receive sediment-laden floodwaters or have channels open through most of the summer. These lakes are invariably surrounded with extensive mats of *Equisetum* spp. Active channels likewise support little growth of aquatic vegetation; turbidity due to particle suspension restricts light, thereby inhibiting photosynthesis (English 1979). The dominant emergent along channels is usually *Equisetum fluviatile* although sedges (*Carex* spp.), cattail (*Typha latifolia*), and *Sparganium* spp. are sometimes common. In the bays along the outer delta these emergents predominate with occasional stands of bulrush (*Scirpus microcarpus*).

E. Hydrology

The Slave River originates at the junction of the Peace River and Peace-Athabasca Delta, approximately 500 river km southeast. It carries over half of Alberta's outflow north as part of the Mackenzie drainage. The flow regime of the Slave River Delta fluctuates directly with changes in outflow from the Peace River and Peace-Athabasca Delta, as there are few tributaries along the Slave River. Fluctuations are therefore moderated, as the Peace-Athabasca Delta accepts much of the peak discharge of the Peace

River.

Peak discharge on the Slave Delta is generally in June, while lowest volumes are in March or April, shortly before breakup. Ice jamming is often responsible for flooding vast areas of the delta during breakup; this recharges low lying areas with sediments and nutrients, and prevents succession to climax vegetation.

The Slave River Delta is actively prograding into Great Slave Lake (English 1979). Maps drawn more than 30 years ago (Law 1950) depicted submergent bar development along the shore of Great Slave Lake. Since then, sandbars have evolved into islands which are now well within the confines of the delta. This progradation of the delta results from the deposition of sediment which is largely precipitated as the fast moving waters of the channels meet Great Slave Lake (English 1979).

F. Historical Importance of the Slave River Delta

The Slave River Delta was historically an integral part of an extensive fur trade route which stretched from the Great Lakes to the Arctic Ocean (Morse 1961). Although it was not as productive in furs as the Mackenzie Delta (Robinson and Robinson 1946), the Slave Delta and Fort Resolution served as a major gathering point for the fur trade and as an important supply and staging base for northern explorations (Smith 1975).

As the fur trade diminished relative to other economic activities, the delta remained a vital link in a major northern transportation route which went from Fort McMurray, Alberta to the Beaufort Sea (Wonders 1966). The completion of the Great Slave Lake railway in 1965, however, shifted this transportation route through Hay River to the west; thus, the delta lost

its role as a transit point. Today, the delta's primary importance is that it provides excellent habitat for a variety of wildlife species, which in turn contributes to the economy of the nearby community of Fort Resolution.

Chapter III

METHODOLOGY

A. Distribution and Abundance of Muskrat Populations

1. Aerial surveys: Aerial censuses were flown periodically (Table 1) over the entire delta to count muskrat houses and pushups. Single engine, fixed-wing aircraft were used, except in August, 1979, when the difficulty of finding houses in high vegetation (particularly *Equisetum fluviatile*) necessitated the use of a helicopter (Bell 206 B Ranger). Censuses were usually flown at 90-110 km/hr and 50-60 m above ground. Due to the small size of the delta and the paucity of water bodies supporting muskrat houses, transects were impractical. Small lakes and sloughs, and bays along the outer delta, were circled several times to attempt accurate counts. House and pushup locations were plotted on sketch maps of the delta while in the air. These were later transcribed to air photo mosaic maps of the delta.

Table 1. Dates of aerial surveys to count muskrat houses and pushups.*

1978	1979	1980
23 June	23 May	------
22 August	9 August	------
17 October	------	16 October
10 November	24 November	------

* Pushup counts were possible only on November surveys.

2. Ground truthing: Whenever water levels and ice conditions permitted access to muskrat lodges seen from the air, ground surveys were used to check the accuracy of aerial counts and determine whether lodges were in use. In the winter, activity of houses and pushups was checked by probing the structures with a steel rod; an open plunge hole was assumed to indicate an active lodge.

Most areas were accessible by boat shortly after breakup, although lower water levels in late summer required overland portages with a small fiberglass canoe to enter some lakes. In the winter, houses and pushups were reconnoitered with snowmobiles and snowshoes.

3. Detection of bank burrows: To detect muskrats where houses or pushups did not exist, general signs, such as tracks, faeces, vegetation runways, and food cuttings were noted. Bank dens were located by constant observations of muskrats during their nocturnal foraging and following them to a burrow. Dens were marked along the bank for future reference.

B. Population Dynamics

1. Carcass Collections: Carcasses were collected each November from trappers participating in the shooting season (which extends from 15 October until freeze-up). Trappers were paid $1.00 for each carcass in 1978 and 1979, and $2.00 in 1980. This was to reimburse them for the value of dog food and encourage them to bring carcasses into Fort Resolution. The date of capture, trapper's name, and location of capture (if known) were recorded for each carcass, which was also tagged upon arrival in Fort Resolution.

Carcasses were later necropsied in the lab and the following characteristics were recorded: age, sex, weight (without skin), total length, tail length, right hind foot length, and presence of parasites or disease. Reproductive tracts of females were retained and examined for placental scars.

Sexes were determined by the presence or absence of a penis, or by internal sex characteristics if the penis was removed during skinning (after Baumgartner and Bellrose 1943).

There are two age classes prior to freeze-up: subadult and adult. Two methods of aging were used. In the first, the shape and size of the penis in the male, and the size (primarily width) of uteri in the female, distinguished adult from subadult (after Baumgartner and Bellrose 1943). Secondly, animals were aged according to the degree of extrusion of the roots of the first molar (Sather 1958).

2. Examination of Lodges for Litters: It was originally intended that the number of young per litter and the number of litters per female would be determined by examining lodges throughout the breeding season. This has been done successfully in many studies, most recently by Westworth (1974) on the Peace-Athabasca Delta. However, due to: 1) the nature of the lodges (being mostly bank burrows); 2) the low population density of the muskrats, and 3) a surely negative reaction from some of the local trappers, this activity was only used to a limited degree. For the effort expended, this task is relatively unproductive as muskrats in houses escape through the water below, and animals in bank dens usually escape through alternate tunnels.

3. Dead-trapping of Pregnant Females: To complement the placental scar counts in carcass collections and to reveal size of litters *in utero* and dates of conception, several pregnant females were collected for necropsy in August 1980. These were shot with the aid of a registered trapper, and examined in the field.

C. Summer Food Selection

Food selection was assessed qualitatively by examining muskrats during their foraging in the twilight of early and midsummer nights. Observations of cut and stored material, and feeding activity in certain vegetation types, were also recorded.

D. Selection of Habitat for Houses and Burrows

1. General surveys: During aerial and ground surveys of the delta, the location of houses and bank dens were plotted on maps. Vegetation, water, and bank characteristics were recorded during ground surveys.

2. Systematic collection of habitat data: Concurrent with a limited live-trapping program, habitat characteristics were assessed in the lakes, bays, and streams of the delta from June until mid-August 1979. At each trapsite, data were recorded to show the vegetation, water depth, and bank characteristics. Categories included: emergent vegetation at the site, submerged plants (raked up from the bottom), vegetation on the bank, distance to bank (in meters), relative bank height (low, slight, moderate, high) and water depth (m).

The collection of data from trapsites in each area then gave an overall picture of the suitability of the habitats for use by muskrats. These data were recorded once in each area over the period of trapping (generally five days and nights) although some areas were revisited later to record changes in water level, plant species, and relative bank height. Monitoring of these sites continued after termination of the live-trapping program.

3. Fall trapping: In late October 1980, the author had the opportunity to accompany several trappers during the fall shooting and trapping season. Precise locations of successful traps were recorded along with habitat characteristics to supplement previous information. By this method, channels which best supported muskrats in the fall could be determined.

E. Assessing Importance of Hydrologic Regime

1. Monitoring of water, snow, and ice levels: Water levels at trapsites of the live-trapping program were monitored during the summers as previously described.

To supplement these data, transects were run through selected bays and lakes to record water depths and vegetation over wider areas. In each case, the canoe was headed on a fixed compass orientation while depth and vegetation were recorded at approximately 5 m intervals.

In late February and early March of 1979 and 1980, ice, snow, and water levels were recorded in various areas of the delta. This information was applied to house and pushup locations and winter survival so that characteristics of optimum winter habitat could be assessed.

CHAPTER IV

PRODUCTIVITY

A. Introduction

Law (1950) considered the muskrats of the Slave River Delta to be "probably reproducing at a normal rate". Notwithstanding his limited field work, however, little is recorded about litter sizes, numbers of litters, and average productivity per female in this wetland. Past muskrat studies (Errington 1937; Cowan 1948; Fuller 1951; McLeod *et al.* 1951) indicate that there are usually fewer litters in northern regions while the yearly productivity per adult female is still as high as in more temperate regions.

The results of investigations of the productivity of muskrats on the Slave River Delta are presented in this section. Placental scar counts yielded the largest, most easily obtained data pool, although these counts normally overemphasized productivity rates. Trapping pregnant females to obtain *in situ* data on litter sizes was largely impractical due to the small muskrat population on the delta. Nonetheless, limited data were obtained from embryo counts and live-trapping records to verify the results of the carcass examinations.

B. Placental Scars

From the 1978, 1979, and 1980 fall carcass collections, there were 33, 12, and 24 adult females. Mean placental scar counts (after resorptions) from these collections were 17.8, 16.4, and 18.3 respectively (Table 2). The three year mean was 17.4 placental scars per adult female.

Table 2. Placental Scar Counts from Fall Carcass Collections.

YEAR	TOTAL NO. CARCASSES	NO. ADULT FEMALES	PERCENTAGE OF ADULT FEMALES IN CARCASS COLLECTIONS	NO. WITH PLACENTAL SCARS	MEAN NO. SCARS	RANGE
1978	297	33	11.1%	33	17.8	2-24
1979	90	12	13.3%	10	16.4	5-21 *
1980	182	24	13.2%	24	18.3	7-22

* Excluding those with no scars.

Table 3 shows productivity estimates obtained from placental scar counts in several studies reported in the literature. Placental scar counts from this study are similar to those reported by McLeod *et al.* (1951) in Manitoba, Gunson (1968) in Saskatchewan, and Schmitke (1971) in Alberta. In the Northwest Territories, Fuller (1951) reported 17.4 placental scars per female on the Peace-Athabasca Delta, a figure which exactly matches the overall mean of this study. Cowan (1948), on the Mackenzie Delta, found an average of 7.4 implanted blastulas per litter (usually two litters were produced).

Placental scar counts for three years show the muskrats on the Slave River Delta to be reproducing at a normal rate for northern deltas. This agrees with Law's (1950) earlier observations on the Slave Delta.

Although placental scar counts are easily obtained sources of data, there are factors which often limit their usefulness as estimators of productivity by themselves. Old scars sometimes persist from previous pregnancies while some recent scars may be masked and difficult to find (Hawley and Hawley 1973). Undetected resorptions of embryos or other intra-uterine factors may further reduce the number of young produced per female below the number obtained through placental scar counts (Fuller 1951). Placental scar counts tend to over-emphasize productivity when compared with other estimators such as embryo counts or nest searches (Cowan 1948; McLeod *et al.* 1951).

Table 3. Placental Scar Counts from Various Muskrat Studies.

RESEARCHERS	YEAR	LOCATION	# SCARS/FEMALE
Arata	1959	Illinois	6.9
Beer and Truax	1950	Wisconsin	15.5
Beshears and Haugen	1953	Alabama	12.7
Cowan	1948	Mackenzie Delta	14.8 = 7.4/litter
Dilworth	1967	New Brunswick	15.4
Fuller	1951	Peace-Athabasca Delta	17.4
Gashwiler	1950	Maine	14.8
Gunson	1968	Saskatchewan	15.3 - 19.4
Hawley and Hawley	1973	Mackenzie Delta	10.8
Highby	1943	Maine	11.5 - 15.2
McCann	1944	Minnesota	11.5
McLeod *et al.*	1951	Manitoba	11.1 - 19.4
Sather	1958	Nebraska	17.6
Schacher and Pelton	1975a	East Tennessee	12.4
Schmitke	1971	Central Alberta	16.2 - 22.8
Sooter	1946	California	14.1
MEAN NUMBER OF PLACENTAL SCARS PER FEMALE FROM ABOVE STUDIES			14.8
MEAN NUMBER OF PLACENTAL SCARS PER FEMALE FROM THIS STUDY			17.4

C. Litter Sizes

1. Embryo Counts: Fourteen pregnant females were collected in August 1980 for examination of litters *in utero*. Mean litter size from this sample was 7.9 (Table 4).

Table 4. Results of *in utero* litter examinations.

No. of pregnant females	Litter size *in utero*
1	6
3	7
7	8
3	9
Total 14 No. females	Mean 7.9 litter size

The mean litter size from this collection is larger than average litters reported from the Mackenzie Delta (Cowan 1948) and from most on the Peace-Athabasca Delta (Fuller 1951; Ambrock and Allison 1972; Westworth 1974). However, the small sample sizes of these studies result in considerable variation. For example, in one collection of the Peace-Athabasca Delta, Westworth (1974) found a mean litter size of 8.9. Litter sizes on the Slave River Delta appear to be similar to those of other northern areas.

2. Litter Size from Placental Scar Counts: Assuming two litters per year, mean litter sizes from placental scar counts for 1978, 1979, and 1980 were 8.9, 8.2, and 9.1, respectively. Over three years, mean litter size was 8.7. These are slightly higher

than Law's (1950) estimate of six or seven, and Fuller's (1951) estimate of seven.

If three litters per female were produced, mean litter size for three years would be 5.8. This seems unlikely, as the *in utero* counts were higher.

D. Number of Litters per Female

Fuller (1951) and Ambrock and Allison (1972) considered two litters were normal in the Peace-Athabasca Delta, although Westworth (1974) found three litters to be a regular occurrence in another area on the same delta. Further north in the Mackenzie River Delta, muskrats produce one and sometimes two litters, although a third has never been reported (Cowan 1948; Stevens 1953; Hawley and Hawley 1973). In southern reaches of the muskrat range, numbers of litters are greater: 2.5-2.6 in Nebraska (Sather 1958) and 5-6 in Louisiana where they are capable of producing 7 or 8 litters per year (O'Neil 1949).

On the basis of placental scar counts and *in utero* examination of collected females, it appears that only two litters are generally produced on the Slave Delta. If three were produced, litter sizes from placental scars would be less than *in utero* observations, whereas they should be greater.

Field observations of parturition periods substantiates these results. Juvenile muskrats were often seen in late June-early July 1979 and mid August 1979, yet not observed at other times during the season. This indicates that two litters were produced, at least in 1979 (a fairly complete year of record). This agrees with results obtained by Law (1950) on the Slave Delta.

CHAPTER V

DISTRIBUTION AND ABUNDANCE

A. Introduction

The incursion of muskrats into habitats containing widely different characteristics of vegetation and climate has not been without adjustments in habitat selection and overwinter survival. Previous studies of muskrats in northern deltas have noted such adjustments. With increasing latitude, muskrats have been forced to specialize in the location and construction of winter lodges. Russell (1898) and Preble (1908) were of the first to note that muskrats make less use of houses in northern latitudes. In the more southerly Peace-Athabasca Delta, muskrats usually build winter houses, primarily in perched basins containing adequate water to prevent winter freeze-out (Fuller 1951; Ambrock and Allison 1972; Westworth 1974; Poll 1980). Farther north in the Mackenzie Delta, where climate is too severe to allow typical houses to be built, muskrats exclusively occupy burrows along lakeshores and enlarge their feeding range with extensive use of pushups (Cowan 1948; Stevens 1953; Hawley and Hawley 1973).

Unlike these other deltas of the Mackenzie basin, the Slave River Delta contains few inter-levee lakes or perched basins; water bodies are formed mainly by the numerous active or abandoned distributaries. For example, English (1979) estimates that 51% - or 107 km^2 - of the delta is submergent (either at or below low summer water level). Of this, 78 km^2 is made up of active distributaries.

Consequently, habitat suitable for the construction of muskrat houses and pushups exists principally in the bays along the outer delta and in the few small lakes.

B. Population Trends from House Counts

In the late 1940's, Law (1950) could find no houses in the few lakes or the bays of the outer delta. He assumed that all muskrats on the Slave River Delta were inhabiting bank burrows, especially in the channels. By contrast, Bodden (unpub.) found muskrat houses and pushups to be abundant in these areas during the 1975-76 peak of the muskrat population. Subsequently, however, the number declined until by June 1978, during the first aerial survey, there were only 39 houses counted on the delta (Table 5). Circular openings - 3 to 4 m in diameter - in the emergent vegetation, and trails radiating from these openings remained as the only remnants of previous muskrat activity.

The number of houses and pushups on the delta remained consistently low up through 1980. During aerial surveys in the fall of 1978, 1979, and 1980, only 21, 18, and 26 houses were recorded, respectively on the delta (Table 5). Comparison of house counts from these surveys with results from surveys completed in the early winter of 1977-78 (Bodden unpub.) shows that there was between a 60% and 100% decrease in the number of houses in certain areas (Table 6). As no estimates of the total number of houses on the delta are available for the period prior to the population decline of 1977-78, it is difficult to determine delta wide population trends from house counts. The limited data available from 1977 to 1980 and the absence

Table 5. Muskrat Houses and Pushups Counted During Aerial Surveys on the Slave River Delta.

	Number of Houses			Number of Pushups		
	Outer delta	Lakes and perched basins	Total	Outer delta	Lakes and perched basins	Total
1978:						
23 June	32	7	39	---	---	---
22 August	11	7	18	---	---	---
17 October	14	7	21	---	5	5
10 November	14	5	19	12	22	34
1979:						
23 May	24	10	34	---	---	---
9 August	12	8	20	---	---	---
24 November	8	10	18	16	42	58
1980:						
16 October	18	8	26	---	12	12

Table 6. Comparison of Fall House Counts in Selected Areas 1977-1980.

	1977	1978		1979		1980	
	(Bodden, unpub.)	No. houses	Decrease from 1977	No. houses	Decrease from 1977	No. houses	Decrease from 1977
Smith Bay	12	3	75%	2	83%	6	50%
Big Rat Lake	17	2	88%	4	76%	---	100%
Harold Balsille Lake	5	2	60%	---	100%	2	60%
Total	34	7	79%	6	82%	8	76%

of any muskrat houses recorded by Law (1950) reveals, however, that there is great inter-annual variability in the number of houses found on the delta. Aerial surveys over the duration of at least two population cycles would be necessary to assess the degree of this variability within different vegetation types.

C. Factors Affecting Surveys of Population Trends

1. Accuracy in habitat types: While the results of yearly surveys for muskrat houses may sometimes reveal gross changes in population status or habitat suitability of certain areas (Poll 1980), they have several limitations. Accuracy varies considerably between different vegetation types (Smith 1974; Poll 1980). On the outer delta this was not a major problem, as *Equisetum* was almost the sole emergent over wide expanses. On the inland lakes, however, overhanging branches and clumps of willow made surveying more difficult.

The accuracy of ground truthing was also variable. Table 7 compares the numbers of houses recorded in selected areas immediately after aerial surveys. In lakes with a narrow band of emergent vegetation 63% more houses were found by ground reconnaissance in summer months. By winter, this decreased to 20%, primarily because visibility from the air was greater when willows had shed their leaves and snow stood out in marked contrast to the houses. Poll (1980) found that fall aerial counts represented only 36.2% to 70.3% of houses counted from the ground on the Peace-Athabasca Delta between 1973 and 1976. Ambrock and Allison (1972) found that aerial survey accuracy was only 50% of the ground counts on the same delta in 1971.

Table 7. Comparison of Aerial and Ground Counts of Muskrat Houses in Different Habitat Types.

	No. Houses Counted		
	Aerial Survey	Ground Survey	% Difference
Lakes:			
May 1979	10	15	+ 50%
August 1979	8	13	+ 63%
November 1979	10	12	+ 20%
Outer Deltas:			
May 1979	24	17	- 29%
August 1979	12	7	- 42%
November 1979	8	6	- 25%

In the outer bays of the Slave River Delta, the relationship between aerial and ground counts was reversed. In late summer only 58% of houses counted during aerial surveys could be located by canoe and on foot. This was primarily because high emergent vegetation and the difficulty of traversing large marshes hindered ground surveys. In the winter, lower vegetation and greater accessibility reduced the inaccuracy of ground truthing; they represented 75% of aerial counts. Wind-blown snow packs and the almost featureless topography lowered the success of winter counts from snowmobiles. The best time for ground surveys in the extensive marshes of the outer delta was immediately after breakup when vegetation was low and water levels were high enough to provide easy accessibility to most areas by canoe.

2. Intra-annual variations in house counts: The same factors which reduced accuracy of aerial surveys between habitat types (Smith 1974; Poll 1980) also affected the precision of house counts on an intra-annual basis. Houses which were mapped and marked with flourescent flags in late May 1979 were virtually impossible to relocate by canoe and foot searches in late July, even though their exact locations were known. A survey by helicopter on 9 August 1979 failed to locate several previously marked houses; intensive searching in specific areas still did not reveal all of these. Many of the houses, however, were inactive when marked in the spring; thus, the lack of feeding activity probably led to the encroachment of nearby vegetation which obscured the houses.

The above factors must be recognized as problems inherent in attempting to compare changes in the inter- and intra-annual abundance of muskrat houses in various habitats. The most important problem on the Slave River Delta, however, is that house counts, whether from the air or ground, may not accurately reflect changes in abundance of muskrats. Even when the proportion of active to inactive houses and the mean number of muskrats per house are known, the obscure nature of bank den locations precludes accurate estimates of population densities.

D. Detection of Bank Dens

Ground surveys were initially intended to reveal the ratio of active houses to active bank dens. It soon became apparent, however, that bank dens were very difficult to locate. Although some researchers have found burrow entrances to be betrayed my murky water or valleys in the mud, (Hawley and Hawley 1973), this was found to be impractical, either from the ground or from the air, in channels with a moderate current. Similarly, detection of den sites by searching for feeding remains also proved to be impractical, as muskrats usually foraged at a considerable distance from the burrow and the river current dispersed much of the food material.

It was found that principal habitats for constructing bank dens were along distributaries; burrows were dug into the sandy silt of moderately sloping levees along which a littoral band of *Equisetum fluviatile* grows. Entrances were found below late summer water levels. Water was sufficiently deep (at least 1 m) near the banks to prevent freezing to the bottom during winter.

Because bank dens could not be systematically located, they cannot be used to estimate population sizes. Further techniques, such as possibly thermo-sensing or a reliable live-trapping program are necessary to determine the ratio of active houses to bank burrows.

CHAPTER VI

HABITAT CHARACTERISTICS

A. Food Selection

Foods reported to be used by muskrats include almost all species of aquatic vegetation, as well as some animal matter (Banfield 1946; Law 1950; Fuller 1951; McLeod *et al.* 1951; Sather 1958; Surrendi and Jorgenson 1971; Schmitke 1971; Banfield 1974). Muskrats are versatile in their feeding habits, so are not restricted solely to eating plants. Errington (1937) has reported muskrats eating "clams, crayfish, frogs, fish, and carcasses of their own kind". Glass (1952) found that fresh water mussels and turtles often constituted a portion of the muskrat diet in Oklahoma. Dilworth (1967) in New Brunswick, Brander (1951, cited in Danell 1978a) in Finland, and Marcstrom (1964) in Sweden also recorded muskrats eating mussels.

The greater portion of the muskrat's diet, however, consists of aquatic plants. Dilworth (1967) recorded at least 32 plant species used by muskrats for food. In southern areas of the muskrat range, long-term studies by Errington (1937, 1963) have shown cattail (*Typha latifolia*) to be the major food item; corn from neighboring farm fields was a significant supplementary item. In northern parts of the range, however, cattail is not always abundant. For example, Ambrock and Allison (1972) found cattail to be a major emergent, along with reed grass (*Phragmites communis*), horsetail (*Equisetum* sp.), bulrush (*Scirpus* spp.). Yet for another study area on the same delta, Westworth (1974) reported cattail to be virtually absent; sweetflag, burreed, and sedge were the major emergents eaten by muskrats. Law (1950), in the Slave River Delta, and Cowan (1948), Stevens (1953), and Hawley and Hawley (1974) in the Mackenzie River Delta, found *Equisetum* to be the major food item of muskrats.

Qualitative observations of foraging muskrats and the cut remains of food revealed that *Equisetum fluviatile* was the major constituent of the muskrat diet in this study. This was probably due more to its accessibility than to preference. Butler (1940), in a quantitative study of muskrat diets, found accessibility to be the major determining factor in food selection by muskrats.

B. Water Requirements for Plant Communities

Water provides for two basic environmental attributes for muskrats - food and shelter. Inasmuch as many of the food species are also used for the construction of shelters, water bodies which allow yearround access to emergent and submerged plants are virtually essential to muskrat populations.

Most of the plant species used by muskrats for food have specific water requirements. Periodic drawdowns which expose mudflats are necessary for the germination of many emergent plants (Harris and Marshall 1963). For example, Weller (1975) found higher rates of cattail (*Typha* spp.) germination in low water and found that vegetative reproduction (suckering) was more successful in shallow (2.5 - 15 cm) than in deep water. Similarly, Dilworth (1967) found cattails died out when flooded to depths of 0.3 to 1.3 m for prolonged periods. On the Slave River Delta, clearage bars - particularly on the outer delta - provide germination sites for cattail, which are often sought out by muskrats for food.

Shallow water is another requirement of aquatic plant communities which are used by muskrats. Deeper water is generally cooler and has less sunlight, thereby restricting photosynthesis. Turbidity is also a major factor limiting the production of aquatic plants, as it inhibits light penetration and smothers plants by precipitation of alluvial material (Chamberlain 1948; Glass 1952; English 1979). In water deeper than 1 m, turbidity due to wind action alone can preclude the establishment of submerged plant communities (Chamberlain 1948)

On the Slave River Delta, English (1979) found that submerged aquatics were fewer in the exposed bays of the outer delta, but were more abundant in the protected zones and inland lakes, where turbidity was less. Submerged aquatics were virtually absent along active channels, except on submerged mud flats near the banks, where *Potamogeton* spp. were ofen found.

C. Accessibility of Food in Standing Water Bodies

Errington (1963) found during his studies of muskrats in Iowa that when pressed, muskrats prefer a good food supply over water depth. In northern climates, however, adequate water is essential to provide access to food supplies in winter (Cowan 1948; Stevens 1953; Surrendi and Jorgenson 1971).

Although small lakes and the protected aress of the outer delta support substantial food supplies, accessibility to the plants is often limited. These areas, therefore, do not always provide good winter habitat.

D. Bank Burrow Habitat

Law (1950) determined 47% of the banks in the Slave River Delta to be suitable for the construction of bank dens. Necessary characteristics are that banks be deep enough to allow access to the water during winter, and high enough (greater than 30 cm) to allow construction of chambers. Those banks along moderately flowing channels which are not exposed to excessive erosion by the current or ice are considered to provide better habitat.

Lakes on the Slave Delta do not provide suitable locations for bank denning as they slope too gently. Hawley and Hawley (1973) found that saucer-shaped lakes in the Mackenzie Delta were prerequisite for the construction of bank dens, as the bank sloped quickly to deeper water.

Although submerged aquatics are not abundant along channels, these waterways provide some of the last vestiges of suitable overwintering habitat. During the early winter most of the smaller distributaries were found to be frozen at their mouths along the outer delta. Consequently, zero flow was recorded in many of these distributaries (Water Survey of Canada 1980). Several of the smaller channels also froze at their proximal ends. During mid-winter these channels provided valuable muskrat habitat, as air spaces under the ice along channel margins provided accessibility to submerged portions of plants, such as *Equisetum fluviatile*. In Sweden, similar hydrologic conditions created this same type of "hang-ice" habitat (Marcstrom 1964).

Larger channels, such as Res delta and Steamboat, did not have an air space under the ice along the banks. This is probably due to the

In the Peace-Athabasca Delta, Ambrock and Allison (1972) determined 61 cm to be the critical minimum depth for optimum overwinter survival of muskrat houses, while Surrendi and Jorgenson (1971) thought up to 2.1 m was needed to sustain pushups. Drastic declines can occur when sufficient depths are not maintained in the winter. Poll (1980) found that, on the Peace-Athabasca Delta, the number of muskrat houses was reduced 67.4% from 1976 to 1979; this he attributed primarily to the failure of spring floodwaters to overtop levees and recharge basins.

On the Slave Delta, the drastic decline in the number of muskrat houses since 1979 is believed to be a result of declining water levels. Virtually all houses reconnoitered during the winters from 1978 to 1980 were inactive; only 2 of 15 houses (13.3%) were in use during the ground survey in March 1980.

Houses in the outer delta were often built atop large pieces of driftwood. Selection of these sites is advantageous to the overwinter survival of muskrats, as it enables the construction of houses in deep water, yet provides a secure base for the house. This aspect of habitat selection has also been noted by Danell (1978a) in Sweden. Even the water around these sites, however, was frozen to the bottom, thereby freezing out muskrats.

Severe cold, direct exposure to strong northwest winds off Great Slave Lake, and a shallow snow cover, combined to freeze the water around muskrat houses in the standing water bodies to depths greather than 1 m. These areas are inferior winter habitat during years of low water, such as experienced since 1978. Monitoring of water, ice, and snow depths over several years, concurrent with studies of muskrat house activity, should be conducted to assess the importance of these areas during high water.

influence of the W.A.C. Bennett dam on the Peace River. Since 1968, water levels have risen on Great Slave Lake each year between October and March (Cheng and Bennett 1975). As virtually 100% of the Slave River winter flow passes through the seven largest channels in the Slave Delta, the smaller channels are exempt from mid-winter rising water levels.

CHAPTER VII
SYNTHESIS

A. Intermediate Nature of Slave River Delta Compared With Other Northern Deltas

This study shows the Slave River Delta to be, in many respects, intermediate between the two larger deltas of the Mackenzie River Basin. The climate of the Slave Delta is not as severe as in the Mackenzie Delta, yet the summer season is shorter and winter weather more severe than in the Peace-Athabasca Delta. Accordingly, the number of muskrat litters is greater than further north yet slightly less than in the southern delta. Litter size, although variable between years, is greater than in the Peace-Athabasca Delta, yet less than in the Mackenzie Delta.

Habitat selection in the Slave Delta also shows some intermediate characteristics between the other deltas. However, there are some significant differences; winter houses are less extensively used, and overwinter survival is poorer, than in the Peace-Athabasca Delta. Unlike features of the Mackenzie Delta, burrows in the Slave Delta are principally found in channels and pushups are rarely used.

B. Variability of Muskrat Habitat on the Slave River Delta

Being essentially a link in habitat between the two larger deltas, the Slave Delta can show, for any given year, a greater similarity to either the Mackenzie or the Peace-Athabasca Delta, depending on the hydrologic and climatic conditions. A favorable year, with a long summer season and sufficient winter water levels, enables a greater chance for third litters and successful overwintering in typical houses, as generally found in the Peace-Athabasca Delta. Conversely, poor weather conditions may result in lower productivity and less exploitation of house building habitat in shallower lakes, a situation analagous to the Mackenzie Delta.

While the Slave Delta has similar characteristics to other major wetlands of the Mackenzie Basin, this extreme variability of winter habitat types is a major difference. Whereas in the Peace-Athabasca or Mackenzie Deltas muskrats must select particular habitats brought about through the rigors of the climate and hydrologic regime, muskrats of the Slave Delta must deal with strikingly different habitat types from year to year. In the Slave Delta, most of the suitable winter house building habitat may be lost in one year due to severe weather conditions, yet re-gained during favorable years.

To have alternate habitat available is beneficial to the long term muskrat population, as temporary refuges or favorable areas can be taken advantage of. However, the great dissimilarities between the two major habitat types on the same delta must be recognized in management plans, since either habitat type may be optimum in a particular year, depending on conditions. Loss of house building habitat would preclude temporarily high muskrat populations, which are of greatest importance to local trappers. On the other hand, if channel habitats were not maintained, the last vestiges of suitable winter habitat in low water years could be eliminated.

The heavy use by muskrats of channel dens, without associated pushups, presents problems in determining distributions and relative densities between specific areas and years, and the vulnerability of channel habitats to hydrological changes. Variation in muskrat house or pushup numbers need not reflect changes in population size; rather, shifts in habitat selection may be caused by changing hydrologic conditions. This may or may not be accompanied by changes in relative population size.

This variability in winter habitat selection by muskrats on the Slave Delta limits the usefulness of information obtained from short-term studies. Attempts to compare muskrat house or pushup numbers on the Slave Delta with results from other deltas are not pertinent when an unknown percentage of the muskrat population may be inhabiting indiscernable bank burrows along channels. These percentages would also be expected to vary under differing habitat and population conditions.

C. Socio-economic and Cultural Considerations

Just as the natural environment of the Slave Delta is unique, so too are the socio-economic and cultural characteristics of the people of Fort Resolution. Fur harvesting has played an important role in the economic development and settlement of most communities in the Canadian North (Robinson and Robinson 1946, Stager 1962, Van Stone 1963). Since the Second World War, many of these posts have become increasingly urbanized such that hunting and trapping have rapidly lost their relative economic importance. Yet some settlements, such as Fort Resolution, have been characterized by conservative factors which have worked "to maintain interest in and dependence on trapping as a means of livelihood" (Van Stone 1963:186).

The culture of the people of Fort Resolution has evolved with substantial dependence on the fur trade (Smith 1975). In the early decades of the 20th century, when Fort Resolution had more fur trading posts than any other settlement in the Northwest Territories (Usher 1971), this community, like others, "became far more irrevocably specialized in terms of trapping and a cash economy" (Fried 1964:56). The high percentage of natives in Fort Resolution, combined with the longer and more intense nature of the fur trade at this post, contributed to the resiliency of this community to modernization, unlike the pattern of neighboring frontier towns such as Ft. Smith and Hay River.

Recent studies have shown that trapping and hunting, especially on the Slave Delta, are still, and will continue to be, very important to the economy of this community. (MaKale and Holloway 1966, Radojicic 1969, Bodden 1981). Further, they have shown that this is more by choice than necessity; recent attempts to establish co-operatives or introduce wage employment have met with little success. Instead, a high value has been placed on the biological resources of the area by the people of Fort Resolution. A recent result has been a decision by the Minister of Indian Affairs and Northern Development to fund a study of the environmental impacts of mining on the south shore of Great Slave Lake (Northern Perspectives 1981).

Understanding the sensitivity of northern ecosystems to changes in their environment is of great significance to the socio-economic well-being of northerners, particularly those who continue to have an intimate association with their landscape. Such concern was well apparent in a recommendation to postpone development of the Mackenzie Valley Pipeline, as it was felt that traditional hunting and trapping lifestyles might be eroded by northern development (Berger 1977).

Changes in the natural environment of the Peace-Athabasca Delta, induced by construction of the Bennett dam in British Columbia, led to reduced productivity of muskrats on the delta; this drastically affected the economy of Fort Chipewyan (Townsend 1972). Any alterations (whether natural or man-made) to the hydrologic regime of the Slave River Delta, can be expected to have equally severe repercussions to the population of Fort Resolution.

D. Research and Management Recommendations

The highly variable characteristics of muskrat habitat on the Slave Delta, and the value of this furbearer resource to the socio-economic fabric of Fort Resolution, necessitate further research to fully understand the response of the muskrat to changes in the hydrologic regime of this delta. Major data gaps exist primarily in some aspects of habitat characteristics, particularly the role of the hydrologic regime in the seasonal and yearly variations in the distribution and survival of muskrat populations. For the reasons discussed above, the following research and management options are recommended:

1) Monitoring of over-winter survival by checking muskrat houses and pushups should continue for at least the duration of two population peaks and drops.

2) Monitoring of winter water, snow, and ice thicknesses should be concurrent with survival checks.

3) Collection of carcasses from trappers each fall and spring can provide easy access to productivity data which can be compared to changing environmental conditions.

4) Another attempt should be made with live-trapping or some other technique capable of distinguishing relative population sizes between channels and standing water bodies. This should also continue over the course of two population peaks so that yearly variations can be revealed.

5) Radio telemmetry or another appropriate technique should be used to help determine the home range and fate of muskrats over-wintering in bank dens so that their vulnerability to changes in the hydrologic

regime might be better assessed.

6) In years of low muskrat numbers, trappers should be prohibited from shooting and trapping muskrats, since their local extirpations of muskrat populations in accessible waterways hampers the recovery of the delta's muskrat populations.

Management of water levels through dikes, dams, or ditching is not considered wise at this time because:

1) The rapidly shifting channels of the Slave Delta might seriously limit the longevity of such measures, and

2) longer term monitoring, such as outlined above, will be necessary to adequately assess the role of the hydrologic regime in the survival and distribution of muskrats on the delta.

[illegible]

[illegible] channels and standing water bodies. [illegible] over the [illegible] of the population [illegible]

8. [illegible] should be [illegible] determine the importance and [illegible] so that their vulnerability to changes in the hydrologic

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